GEOLOGICAL SURVEY

OF

ALABAMA.

EUGENE ALLEN [redacted], PH. D., STATE GEOLOGIST.

BULLETIN No. 5.

A PRELIMINARY REPORT ON THE

MINERAL RESOURCES

OF THE

UPPER GOLD BELT,

With Supplementary Notes on the Most Important Varieties of the Crystalline or Metamorphic Rocks of Alabama.

WITH THREE PLATES.

MONTGOMERY, ALA., 1896:
JAS. P. ARMSTRONG, PRINTER.

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PART I.

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UPPER GOLD BELT OF ALABAMA,

in the Counties of Cleburne, Randolph, Clay, Talladega, Elmore, Coosa and Tallapoosa.

BY

WM. M. BREWER, Assistant.

PART II.

Supplementary Notes on the Most Important Varieties of the Metamorphic or Crystalline Rocks of Alabama, their Composition, Distribution, Structure, and Microscopic Characters. By EUGENE A. SMITH, GEO. W. HAWES, J. M. CLEMENTS AND A. H. BROOKS.

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rocks examined under the microscope, have yielded more abundant and at the same time more certain and definite information concerning the origin and history of these rocks together with their mineral contents, than almost all other methods of investigation combined. If we are to keep at all in line with the progress of the world in the study and presentation of our natural resources, it will not do to neglect any of the sources of information which modern methods of scientific investigation place at our disposal.

We are therefore to be accounted fortunate in having the notes of Dr. Clements and Mr. Brooks upon some of our typical rock varieties, and our obligations to these gentlemen, and to the authorities of the United States Geological Survey, with which Mr. Brooks is connected, are not lessened by the circumstance that these notes have been contributed without cost to our State Survey.

Very respectfully,

EUGENE A. SMITH,

University of Alabama, June 15, 1896.

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PART I.

A PRELIMINARY REPORT ON THE

UPPER GOLD BELT OF ALABAMA.

IN THE COUNTIES OF CLEBURNE, RANDOLPH, CLAY, TALLADEGA, ELMORE, COOSA, AND TALLAPOOSA.

BY

WILLIAM M. BREWER.

LETTER OF TRANSMITTAL.

To Dr. Eugene A. Smith,
State Geologist:

DEAR SIR :—With this I hand you my report on the gold occurrences of the Upper Belt of the Alabama Gold Regions.

The field work which furnishes the material for the greater part of these notes was done during the summers of 1893–4. Since that time, however, I have had occasion to revisit several parts of the field where active work of prospecting or mining was being carried on, and to revise the notes, and bring them up to date. This will explain the lack of compactness or unity in some of the descriptions, especially of the Pinetucky, Idaho and Arbacoochee Districts.

In describing the gold deposits, I have in this report, commonly spoken of them as bedded veins, stratified deposits, etc., and have made use of the terms stratification, strata, and beds, in connection with the rocks of the country. These are the terms most naturally suggested by the general appearances, and they will perhaps be better understood by the majority of those who may make use of this report.

I am aware, however, of the fact that the structure of these crystalline rocks may in many cases have no connection with stratification, since the fully crystalline schists are now generally considered to have been derived by metamorphism from massive igneous rocks, and even in the rocks of sedimentary origin—like the Talladega slates—the planes of cleavage may not necessarily be the planes of original stratification.

With this explanation I trust that my use of the terms

above indicated may not be wholly objectionable, although strict accuracy would perhaps suggest that they be discarded, and the terms "*Stringer-leads*," "*Linked veins*," "*Schistosity*," and "*Schists*," etc., be substituted.

WM. M. BREWER.

Heflin, Ala., April 10th, 1896.

THE UPPER GOLD BELT.

In the report of Dr. Wm. B. Phillips (Bulletin No. 3) on the Lower Gold Belt of Alabama, he refers to a division of the gold fields of the State into "Upper" and "Lower" for convenience of reference.

The dividing line, which is the boundary between the counties of Talladega, Clay and Randolph, on the north, and Coosa, Tallapoosa, and Chambers on the south, I have respected in my examinations.

Beyond the connecting of the formation of the distinct leads of gold bearing ore, and the determining of the continuity along the line of strike of these leads which have their south-western terminations in the Lower Gold Belt, no reference will be found in this report to occurrence of gold bearing ore south of this dividing line, except in some cases not referred to in Dr. Phillips' report, because of his being called from the field by the reason of sickness in his family, before the completion of his survey.

Consequently, while this report is on the Upper Gold Belt as just defined, the first pages are devoted to a further description of that section of the Lower, omitted by Dr. Phillips in his report above cited.

SILVER HILL BELT.

TOPOGRAPHICAL AND GEOLOGICAL FEATURES.

The name above given was taken from the mine situated in the hill locally known by that name, in Secs. 16 and 17, T. 20, R. 22; and about 1½ miles south of that prominent feature of the landscape, mentioned both by Prof. Tuomey in his report dated 1858, and Dr. Phillips in his, dated 1892, and referred to by them as the "Devil's Back-bone."

The fact that this is the most south-easterly of any belt or series of leads of gold-bearing ore in the State, is one of my reasons for taking it up first in my report.

In both the reports above referred to, no particular mention is made of the extent longitudinally of this bold ridge, or of the location of its south-western extremity which I found to be in Sec. 18, T. 19, R. 21 in Elmore county, about 2 miles north-east of Eclectic P. O. There it is that the 'Talladega' semi-crystalline slate is first seen as one travels north-east from Wetumpka; and there also is the point where the ridge, which extends as a bold feature of the landscape across this section of the State, and into Georgia, first assumes definite outlines.

The name of "Devil's Back-bone" does not receive local recognition in Elmore county, nor does the ridge assume its full proportions so far as height and barrenness are concerned until it crosses into Tallapoosa county at the extreme north-east corner of Elmore county.

The strata of semi-crystalline slate and quartzite which compose this ridge have their lines of strike north-east and south-west with a south-east dip, and consequently the ridge itself possesses the same trend, maintaining its continuity persistently in this portion of Elmore county,

except where it is cut through by Channahatchee and Kielijah creeks.

MINING OPERATIONS.

Channahatchee Creek and Peru Branch.

While gold has been discovered immediately on the crest of this ridge in Tallapoosa county, yet so far as at present known, such is not the case in Elmore. Limited prospecting work has been done in years past on Channahatchee creek,but such was abandoned, almost beyond the recollection of the oldest settlers;and despite recent excitements on the north-eastern side of the river on this belt of semi-crystalline slate, in which several gold-bearing ore bodies have been discovered, no one has faith enough to prospect this ridge on the south-western side.

This "Devil's Back-bone" ridge crosses the Tallapoosa river in Sec. 32, T. 21, R. 22, and preserving its general characteristics in a north-easterly course, crosses the Columbus and Western Railroad at Jackson's Gap Station; and again crosses the Tallapoosa river near the northern borders of the Horse Shoe Bend in which is located the old battle ground where Gen. Jackson routed the Indians.

The "New Yorker Shoals" also cross the river in the same vicinity in Sec. 24, T. 23, R. 23 E. or to locate the crossing exactly, this range line follows the river which at this point runs north for a short distance. The "Devil's Back-bone," while its course can be readily traced to the north-east, across the Tallapoosa for the third time, near Denny's ferry in the north-western corner of Chambers county, thence across Randolph county and into Georgia, does not form as prominent a land mark as in the vicinity of the gold mining district in Tallapoosa county. The semi-crystalline Talladega slates and quartzites form the ridge and its flanks throughout this entire distance, and many of the occur-

rences of gold-bearing quartz are associated with these rocks.

Besides the old workings referred to already, on Channahatchee Chreek, I was also informed of other prospecting which had been done in the past in Elmore county in this vicinity on Peru Branch. But it is impossible to get any thoroughly reliable information as to the results of this early work, which was carried on in the most primitive methods of gold mining, and only the ore near the surface which was thoroughly oxidised was treated, together with any placer gravel beds that occurred on the creeks and branches.

Silver Hill, Blue Hill, and Northeastward.

One fact is noticeable throughout this Silver Hill belt; from beyond Blue Hill, which is located in Sec. 33, T. 21, R. 22, in a north-easterly direction, no prospecting has been done anywhere on the bold and prominent quartz outcroppings, which rise above the apex of the ridge proper, in many places, to the height of 10 or 12 feet. These outcroppings are composed of a sugary quartz, many samples from which, I found, panned colors; as also was ascertained by Dr. Phillips.* The reason why no work has been carried on is obvious, for except where this ridge is cross cut by the river and creeks, to obtain the water supply necessary for conducting mining and milling operations would require the investment of large capital to render it available.

For this reason, as well as because the ore is invariably richer, all mining, except in the immediate vicinity of Blue and Silver Hills, has been carried on in the less prominent ridges in the same country rock, which parallel the Back-bone proper.

In traveling to the north-east from Blue Hill I found

*Bulletin No. 3, Alabama Geological Survey.

that the gold-bearing quartz and graphitic slates were not as closely associated as is the case at Blue and Gregory Hills (both in the same land section), where the two become a conglomerated mass so intermixed and irregular in structure that it is impossible to separate the one from the other, and the entire hill sides are quarried down and sent to the mill. This product from the mines was yielding, at the time of my visit, about $2.00 a ton, or rather that amount was saved. I am of opinion though, after panning several average samples, that at least double this amount would be saved, were some process devised for eliminating the graphite before amalgamation was attempted. Apart from this graphite the ore which I saw mined at Blue Hill had no refractory characteristics, but in the other mines in the vicinity the ore is heavily sulphuretted, even at shallow depth. A sample of ore from the Nichols opening, near Blue Hill, gave on analysis $8.66 per ton. This ore has very little graphite. The Devil's Backbone, and indeed the entire belt of semi-crystaline slates are partially or entirely cross cut at irregular intervals by the waters of Big Sandy Creek, at Pace's mill, Sec. 15, T. 21, R. 22 E.; by Manoa Creek, Sec. 34, T. 22, R. 22 E.; by Jackson's Gap cut on the Columbus and Western Railroad, Sec. 13, T. 22, R. 22 E.; by the Tallapoosa River at Horseshoe Bend, already referred to; by Jay Bird Creek between Jackson's Gap and the Horseshoe Bend, Sec. 33, T. 22, R. 23 E.; by Galloway Creek and Hardnett's Mill Creek, two miles south of Daviston P. O. near the northeast corner of Tallapoosa county; by the Tallapoosa River at Denny's Ferry in Chambers county, and by some of the head-waters of High Pine Creek in Randolph county; as well as by the headwaters of Wehadkee Creek in the same county near the State line.

Jackson's Gap, which I have referred to as cross cutting the Backbone, affords a good opportunity for studying

the formation and structure of this ridge. In a deep cut made by the railroad, about 25 feet in depth and 400 in length, I noticed that the strata of slate and quartz have been twisted and folded into snake-like contortions, having no regularity in dip or thickness, as depth is attained. The stringers of quartz are interpolated between the slates, without any conformity, and having a lenticular or kidney-like structure. A thick outcrop at the surface in several places pinches out a few feet below; while in other instances although no outcrop occurs at the surface, yet 10 or 20 feet below kidneys of quartz are seen imbedded between the slates in masses and pockets; in one case, attaining a thickness of several feet at the bottom or floor of the cut, and this body of quartz extended below the bottom or floor of the cut.

From the formation in this cut, also from the fact that the Bonner-Terrell and Gunn properties located on a parallel ridge possess the same structure, I am inclined to the opinion that gold mining in this vicinity would prove quite uncertain.

In width, I find that this belt of semi-crystalline slate with the associated gold-bearing ore, is more extensive than is generally supposed. While the main lead apparently outcrops along the crest of the Devil's Backbone, I observed outcrops and old workings, at many points along the line of strike of the belt, more than a mile and a half to the south-east; but the Devil's Backbone apparently marks the line of the northwestern border; beyond which you pass at once into gneiss and mica-schist.

Bonner-Terrell Mine and Vicinity.—In the vicinity of Jackson's Gap there are only two known evidences of gold bearing ore. These are the Bonner-Terrell and Preacher Gunn properties. The first named is located on Sec. 19, T. 12, R. 23. It was worked to some extent, as the old openings demonstrate, some years since, and a

stamp mill was run on the ore; but for some reasons the old openings were abandoned and allowed to cave in, the mill was torn down and moved away, and to-day it is impossible to form any idea from an examination as to the extent or value of the ore.

The last named is located on Sec. 30, T. 22, R. 23. Here only shallow prospecting has been attempted. Some samples from a narrow seam of quartz bedded conformably with the country rock panned quite richly, but the formation is apparently similar to that at Jackson's Gap with regard to structure, and the work is entirely insufficient to warrant any opinion regarding the prospect; beyond the statement that some of the quartz carries gold. At another point on this same property a shallow pit exposes a seam of ore about 18 in. or 2 feet in thickness. This however does not pan as richly as the thin streak, while the same facts exist as to work, etc.

Eagle Creek Gold Mining District.

This is the local name given to that portion of the Silver Hill belt which lies adjacent to and in the vicinity of the Horseshoe Bend of the Tallapoosa River, and the New Yorker Shoals. The name is taken from that of a creek which empties into the Tallapoosa River on the southeast side near the New Yorker Shoals.

This district on both sides of the river was quite extensively worked several years ago, and a stamp mill, or as it was then called, a ''pounding mill,'' was operated on ore mined from near the surface; but work was abandoned when sulphurets were encountered. Since then the old openings have been allowed to cave in and fill up with debris, so that it was with difficulty I could enter the same, and examine the ore bodies.

These occurrences were not on the Devil's Backbone ridge proper, or *Sheep Hill*, as this portion of the ridge

is locally called, but on ridges having their trend nearly parallel with the main ridge, and located about one mile to the southward of it.

Jennings', S. W. Sec. 26, T. 23, R. 23 E.—This property is the southwestern-most in this district on which a body of gold-bearing ore has been discovered and prospected to some extent. There appears a slight change in the character of the country rock; which has the appearance of a hydro-mica schist rather than the semi-crystalline "Talladega" slate. The ore is a somewhat sugary decomposed quartz, and the body I examined was a seam some 6 to 8 inches in thickness in apparent conformity with the country rock. The openings in this property were all shallow prospect pits, and beyond the fact that it panned at about the rate of $3.00 or $4.00 a ton, but little could be determined as to structure or permanency.

Tapley, S. E. Sec. 26, T. 23, R. 23, E.—This property adjoins the Jennings, and is apparently an extension of that ore body. The openings were more numerous and extensive. In fact in one place ore had been mined a depth of 50 feet, but so long ago that the timbering had rotted and the openings were inaccessible. Some of the ore remained on the old dumps. This was a whitish flinty quartz, highly sulphuretted, and quite undesirable for treatment by amalgamation. Several tons of ore from this property had been treated in the mill already referred to, but no reliable information could be obtained as to the results.

Where I was able to see this ore body I found it showed about the same thickness as on the Jennings property, with its line of strike N. E. and S. W. and dipping at an angle of about 45 deg. slightly E. of S. There are also several thin stringers of a bluish colored, hard sulphuretted quartz on these properties; all of

which show gold by panning, so far as I was able to test them.

Hammock, S. W. Sec. 24, T. 23, R. 23, E.—This property was mined on about 12 years since, and the mill above referred to was then in operation on a branch which flows through the property. Nothing now remains to mark the spot where the mill stood except some rotten timbers, and an old ore dump. It is claimed that some of the ore from this property milled $30.00 a ton in free gold, but a sample I took from the dump, assayed only $5.70 a ton in gold. The ore resembles the Tapley; being a highly sulphuretted hard quartz. The sample I took was, as near as I could judge, without systematic sampling, a fair average of a few tons which still remained on the dump. Milling and mining were suspended, it is claimed, because the ore was too highly sulphuretted to work profitably by ordinary amalgamation. No information whatever could be gathered from the old openings.

Greer, S. E. Sec. 24, T. 23, R. 23. E.—From the Hammock property I traced the same lead of quartz by the outcrop, to the Greer, which extends to the Mule-shoe Bend of the Tallapoosa River, situated partially in the eastern portion of this same section. The ore here has the same general characteristics as in all the openings, as well as in the outcroppings, through this district, and apparently is of about the same relative value. From the best information I could obtain, ore from all these properties in this district on this side of the river was milled in the Hammock mill some 12 years since; but no work has been done recently, except that some of the shallow pits were partially cleaned out to enable me to see the ore body, which has the structure of a bedded vein, in the hydro-mica schist country rock, conformably with the general formation and having its line of strike N. E. and

S. W., and dipping at an angle of about 45 deg. towards S. E.

Crossing the river at the Griffin ferry in Sec. 24, T. 23, R. 23 E., I continued my work of tracing this gold lead or belt by actually following along the line of strike of the formation towards the Georgia-Alabama State line.

In this I found some difficulty, because except in the vicinity of the river, the outcrop had lost some of the bold and prominent features it possessed towards the S. W. As nearly as I could trace it by the country rock, which along the south-eastern border of the belt still maintained those characteristics which led me to classify it as a hydro-mica schist, but towards the north-western border preserved the appearance typical of the "Talladega" semi-crystalline slate, I found that the belt continued along the summit and sides of a well defined ridge. Though not as prominent a land-mark as the Devil's Back-bone to the south-west, yet it was sufficiently persistent to be considered an extension of that ridge.

Johnson, W. half of S. W. Sec. 17, T. 23, R. 24. There are several old workings in this vicinity, consisting of tunnels and shallow incline shafts which were made in 1840 to 1845; when, judging from the old dumps and the extent of the workings, quite extensive mining operations were carried on.

This Johnson property is located in the forks of the river and Sweet Water creek on the north, or rather north-west, side of the river. The outcrop of quartz, much of which prospects, is quite bold and prominent, continuing along the line of strike N. E. and S. W. with hardly a break, to the river, a distance of about a mile and a half.

The character of this quartz is sandy, sugary, very much stained with iron oxide, partially decomposed and porous.

A sample selected at haphazard, analyzed by Dr. J. H. Pratt of Birmingham, Ala., yielded $3.43 a ton in gold. In panning several samples I noticed that the results averaged very evenly, more so than almost any other quartz outcrop I have tested in this State. These were all taken at haphazard from the outcrop, and were not sampled systematically by quartering as should be done; but I lacked both time and facilities for doing such work.

As is the case on the opposite side of the river, some work was done here ten or twelve years since, and ore milled. At the present time, though the openings are in such a condition that it is impossible to estimate the character or extent of the ore body, except from the outcrop, which, while it has a general line of strike and dip, has but little regularity in structure.

The gold contained in this ore is very fine, but appears to be free-milling at and near the surface, though undoubtedly sulphurets will be present at depth. To the south-west on the

Griffin property, Sec. 19, T. 23, R. 24 E., the same lead of quartz, apparently, can be traced across that tract from which it enters the river. No work of any description had been performed here at the time of my visit, nor indeed could I learn of any other mining work, having been carried on along the line of strike of this Silver Hill belt to the north-east in this State.

My attention was attracted to the different appearance and nature of the quartz occurring in the several leads on the two sides of the river, in the Devil's Back-bone proper, as well as in the parallel ridges, a mile or more to the south-east, where most of the mining has been done. While the gold-bearing ore on the northern side of the Tallapoosa, so far as I observed (and I saw, and tested samples by panning, from all the known bodies which outcrop, or have been mined), is of a sugary,

sandy character, somewhat decomposed and porous, and plentifully stained with iron oxide; that on the southern side, especially in the southeastern-most bodies, is of a hard, glossy and flinty nature, carrying a large per centage of sulphurets, and some magnetic iron.

North-East of Eagle Creek District.

To the north-east along the line of strike of the country rock, I traced this belt across Galloway creek about 2 miles south of Daviston, where I found apparently the same ledge of slate as at the New Yorker Shoals with quartz interpolated between the strata. Thence to Hardnett's Mill creek, two and a half miles further to the north-east, where the same ledge crosses the creek a short distance north of the mill. Thence to the Mountain Spring church on the Chambers county line, Sec. 19, T. 24 N., R. 25 E.

A short distance from this church, to the north-east, in the same section, and along the crest of a high ridge, from which the church derives its name, the outcrop of quartz again assumes the bold outlines it possessed along the Devil's Backbone in the vicinity of Blue Hill, and rises several feet above the surface in immense slabs and boulders. Some of this quartz is in place, but no enclosing walls of country rock are exposed, except in such a rotten state as to render its classification quite difficult. Near by, though where less decomposition and erosion have taken place, the country rock, are the same semi-crystalline slate and hydro-mica schist, which characterize the entire belt. The dip of this quartz in places is almost vertical, and the strike conforms with the general line N. 40° E. This quartz is of the same sandy, friable character as in the outcrop along the Devil's Back-bone proper, but samples I took failed to show any colors of gold in the pan, although the presence of black sand with some sulphurets indicated that

there might be gold bearing chutes or chimneys in the body. I followed this outcrop along the ridge and towards the Tallapoosa river, which it crosses at the mouth of Laney creek, about one mile below Denny's Ferry, and five miles due east from Daviston. I could find no openings on this outcrop along the ridge, or in this semi-crystalline formation in this vicinity, to indicate that any prospecting had been done, nor could I learn of any work which resulted profitably having been performed on this Silver Hill belt north-east of the river at any point between it and the Alabama-Georgia Line.

The belt of semi-crystalline slate and hydro-mica schist maintains its continuity, with many seams of quartz interstratified, as I demonstrated by crossing the formation at various points along its line of strike. The course is north-easterly from Denny's Ferry across the north-western corner of Chambers county; thence into Randolph south-east of Louina, crossing the county, passing near Handley P. O., thence to the State line.

Near Rock Mills, Randolph County, about five miles in a direction slightly north of east from Roanoke, and in Sec. 27, T. 21, R. 13 E., it is reported that while the Indians resided in that vicinity, as well as more recently, placer gold has been found in the bed of Wehadkee creek, but no signs of any extensive work can be found.

So far as I could ascertain the occurrence of gold in this section is based entirely on legend and tradition; many stories of the Indians bringing gold dust to the traders in small quantities are related by early settlers, but no one appears to place sufficient faith in such accounts to feel warranted in expending money for prospecting during recent years.

So far as I could discover from my own tests, as well as the best information I could obtain on the subject, I feel warranted in stating that no gold in paying quant-

ities occurs in Alabama south-east of the Silver Hill belt; although the crystalline schists, hornblende and gneiss formations continue in a south-easterly direction some 40 miles, or to the latitude of Columbus, Ga.

OCCURRENCES OF MICA, CORUNDUM, SOAPSTONE AND ASBESTOS.

Immediately south-east of the Silver Hill belt, and paralleling the same, we find first strata of graphitic slate, which I noticed at one point on the Germany Ferry road between Daviston and Dadeville on the north-west side of the Tallapoosa river, to be at least 40 feet in width where the public road cross cuts the slates. Next in the series of mineral belts paralleling the Silver Hill, are veins of coarse grained granite, from which mica in crystals sufficiently large to possess a commercial value, has been mined. I found the best points to study these parallel belts was in the vicinity of Dadeville and Buttston, also near Easton P. O. about 7 miles northerly from Dadeville.

From my observations in this neighborhood, I found that the mica belt just referred to, was followed by a belt of soapstone.* Associated with which were corundum and asbestos. In its turn the soapstone was followed by another belt or series of veins of coarse grained gneiss, and mica schist which indicated the occurrence of mica of commercial value.

This last occurrence of mica together with the soapstone and other minerals are what is locally known as the mica, corundum and asbestos belts; which parallel the strata of graphitic slate, in their turn paralleling the Silver Hill gold belt on the south-east border.

I have observed in Carroll county, Ga., apparently the same series of mineral bearing formations; which cross

*The soapstone, and other minerals here mentioned, are associated with masses of basic igneous rocks (pyronene and chrysolite) and some of them—soapstone chlorite and are the products of the alteration of these by weathering. E. A. S.

that county in a north-easterly course. Although the outcrops are not continuous above the surface, yet I am of opinion from the general character of the formations that these belts are south-western extensions of those in Georgia. Especially, as I am reliably informed since the same occur in Heard county, Ga.

So far as I could ascertain the only work of any extent that had been performed in search for

Mica in this neighborhood, or indeed anywhere on this belt, was on the Holly plantation about 2 miles east of Easton P. O. Here a pit some 15 feet deep had been recently sunk and merchantable mica mined and shipped to St. Louis. But at the time of my visit (Nov., 1893,) the work was suspended, and from the manner in which it had been done, it was impossible for me to form any idea of the permanency of the deposit.

Immediately north of this belt bearing mica, extends what is locally known as the

Corundum and Soapstone belts where about 12 years since Dr. Lucas, a resident of North Carolina, who had purchased a tract of land on the Tallapoosa river, including a portion of the New Yorker shoals, with the avowed intention of utilizing the water power for manufacturing purposes, gave the industry of corundum mining quite an impetus by purchasing the product of this belt. He paid from $50.00 to $60.00 a ton, but was driven from the market by another dealer, who for a time paid a higher price, but ultimately failed. Since then the industry has been entirely abandoned in this section of the State.. I visited some old openings that were made at that time on the Hanby plantation, adjoining the property, on which is located Easton P. O. on the east; also at the Bartlett plantation 2 miles north of Dudleyville, and the Holly plantation 2 miles north of Hanby's.

At the last named, soapstone only had been found, and mined to a limited extent; some of the blocks which had

been sawed out at the time active mining operations were being carried on, still remain on the ground.

Whether sufficient corundum can be found in the beds on this belt, to be of commercial importance in the future, is impossible to estimate. The old openings are partially filled up with debris, and apparently were sunk until a hard variety of soapstone was encountered and then abandoned.

I find this corundum and soapstone belt extends as far to the south-west as the vicinity of Dadeville, and to the north-east in the neighborhood of Milltown, but as to the exact extent longitudinally, I have not determined.* In width it is of inconsiderable extent so far as at present known; not exceeding 2 miles, so far as I can learn, at any point.

There apparently occur two series of beds with parallel lines of strike; both of which cross the Hanby plantation, before referred to; but I can find no trace of the occurrence of any corundum or soapstone north of the Bartlett plantation and south of the Silver Hill gold belt. This last named property is in a line north-east from the Hanby, and distant about 5 miles.

On the Germany Ferry road to Dadeville the most northern indications of corundum and soapstone occur at the crossing of Soapstone Creek 2 miles south of the ferry. At this point immense outcroppings and a ledge of chrysolite rock show in the wagon road, which apparently has close connection with the soapstone corundum beds; for the same rock is again found on the Griffin Ferry and Dadeville road near an old church, in the northern portion of T. 22, R. 24 E., as well as at other places along the line of strike.

*Another somewhat similar belt is on the N. W. side of the Devil's Backbone ridge, showing near Foshee's Mill (Fosheeton) and far to the southwestward at Robert Goodman's, south of Alexander City. At Goodman's a considerable quantity of corundum has been observed. E. A. S.

I also found some samples of

Asbestos closely associated with the corundum and soapstone, at the Bartlett plantation, but of a very poor quality; as good, however, as that found in Carroll county, Ga., which at a depth of 12 feet was not of sufficiently good grade to command any commercial value.

Whether the grade will improve as depth is attained in the workings I am unable to state; but so far as I could learn from personal observation or information, no work has been done on the Alabama side to determine this.

One and a half miles north of the Bartlett plantation the Tallapoosa River flows, and between these points some mica has been found, along that northerly belt I have referred to already, as paralleling the graphitic slate, but of inconsiderable quantity, so far as at present developed.

The country rock associated with the corundum and asbestos is a talcoid-schist; with boulders of soapstone, and a green colored rock probably chrysolite, there are also specimens of actinolite and tourmaline plentifully found with the float and surface rocks. A ledge of dark green hornblendic rock is also a noticeable feature in the geological formation, which I have failed to find elsewhere in this crystalline region, except along the line of strike of these particular belts. The largest outcrop of this is near Dudleyville, where the wagon road cross cuts it angling. * This is on the road between Dudleyville and Buttston.

The mica-schist and gneiss formations are continuous paralleling the Silver Hill belt on the S. E. to the Alabama-Georgia boundary line, crossing Randolph county through Roanoke, thence by Rock Mills to the line, into Heard County, Ga.

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* See foot note to page 18. E. A. S.

GOLDVILLE AND HOG MOUNTAIN BELT.

In my report I have retained the same name for the upper portion of this belt, which occurs to the north-west of and paralleling the Silver Hill, as that used by Dr. Phillips in his report on the Lower Gold Belt. My examination of this began in Clay county; because in the report of Dr. Phillips above mentioned, the south-western portion of this belt has been fully, and very ably described.

TOPOGRAPHICAL AND GEOLOGICAL FEATURES.

Before taking up the description of the gold leads on this belt, I will occupy a little space in briefly describing the geological formation of the fully crystalline region which intervenes between the Silver Hill belt of semi-crystalline slate and hydro-mica schist, and this Goldville belt, which is formed by the Talladega and other semi-crystalline slates; with boundaries of gniess and flat rocks, usually called granite, both along the south-east and north-west borders.

The average distance intervening between these belts is about 6 miles, which can be definitely traced on the map, by drawing a line with a N. E. S. W course intersecting Daviston on the north-western boundary of the Silver Hill belt and New Site on the south-eastern boundary of the Goldville belt. In Randolph county the semi-crystalline slates are greater in width than in Clay or Tallapoosa counties, and have intruded on the fully crystalline, or vice-versa; for it is not yet decided which formation is the older. This intrusion* is

*See Part II of this Report, where reasons are given for thinking that the structure of these crystalline rocks is not *stratification*, but a secondary character (*schistosity*) produced by dynamic metamorphism of originally massive igneous rocks. E, A. S.

really interstratification; because the series of the formation follow each other conformably. But alteration appears to have taken place along the line of the strike; so that in traveling across the formation from Louina to Almond P. O. a series of strata of semi-crystalline slate occur, which are not seen south of the Clay county line. While in traveling from Roanoke to Wedowee these fully crystalline schists and gneiss appear to be narrowing down, and about 1 mile east of Wedowee disappear entirely, with the exception of about 100 acres of gneiss and flat rock occurring about 2 miles north.east of Wedowee, portions of Sec. 23 and 24, T. 19, R. 11 E. Immediately paralleling the Silver Hill belt on the north-west in the vicinity of the Eagle Creek Mining District I found massive boulders and beds of gneiss, which maintain their continuity longitudinally to the Alabama-Georgia State line. On the line of strike towards the north-east this bedded gneiss assumes the structure of

Flat Rocks in many places on both borders, and is usually designated as granite, and often as dikes. But although these flat rocks in some places cover several acres, as at Almond P. O., (at that place the flat rocks cover nearly or quite 200 acres, being 2 miles in length N. E. and S. W. and $\frac{3}{4}$ mile wide,) I find the lines of stratigraphy* quite well defined, showing conformity in the bedding with the semi-crystalline slates on both S. E. and N. W. The same state of facts I find on close observation prevails wherever these flat rocks occur, consequently instead of treating them, and writing of them as granites, I shall refer to them always as gneiss. As these occurrences are possessed of a commercial value, I have taken pains to locate the most prominent in this portion of the State as follows:

Almond, S. E. of Sec. 29, S. W. Sec. 28, T. 21, R. 10 E.

*See preceding foot-note. E. A. S.

Almond, Sec. 5, T. 22 S, R. 10 E.
Motley Mill, Sec. 4, T. 24 N. R. 24 E.
Handley, Sec. 22, T. 20 S., R. 12 E.
Forester's Chapel, Sec. 29, T. 21, R. 11 E.
Portions of Secs. 28 and 27, T. 21, R. 10 E.
Rock Mills, Sec. 27, T. 21, R. 13 E.

The foregoing all occur on the north-western border of the Silver Hill belt, except the exposures at Rock Mills, which is in the crystalline region south-east of this belt.

The exposures along the line of strike of the gneiss forming the north-western boundary of the Goldville belt, are as follows:

Knight's Mill, Sec. 35, T. 20, R. 9 E.
Carwile, S. E ¼. Sec. 34, T. 20, R. 9 E.
Wm. Orr, N. W ¼. Sec. 35, T. 20, R. 9 E.
Dawkins, Sec. 8, T. 21, R. 9 E.
Grizzle, N. W ¼. Sec. 24, T. 20, R. 9 E.
Blake, N ½ S. E ¼. Sec. 18, T. 20, R. 10 E.
Blake, S½, N. E ¼. Sec. 18, T. 20, R. 10 E.
Devon, S. W ½. Sec. 18, T. 20, R. 10 E.
Moore and Duke, portions of Sec. 23 and 24, T. 19, R. 11.

The only place where any quarrying is at present being carried on is on the last named exposure, which is two and three-fourths miles north of Wedowee. Here a firm of bridge builders, the Alabama Bridge Company, are quarrying the rock for piers and abutments for a new bridge across the Little Tallapoosa river on the wagon road to Heflin. About 500 tons will be quarried for this purpose, and the rock is pronounced as of a very superior quality. An ample supply, I was informed by the contractors, will be obtained without the necessity of quarrying to any considerable depth; in fact, at present, only the rocks which have become split by weathering have been used.

I can not learn of this rock having been quarried and used for building purposes within the boundaries of the Upper Gold Belt, but such has been done at Rockford and Goodwater in Coosa county with very satisfactory results. The rock from that vicinity has the same characteristics as that found in Randolph county, where such rock has hitherto only been utilized for gravestones, mill stones and chimneys.

These belts of gneiss are followed on the south-eastern border of the Goldville belt by the semi-crystalline Talladega slate. The general dip of this entire Upper Gold belt section of the crystalline region inclines towards the east and south-east. The structure is, I notice, generally conformable at the lines of demarcation between the gneiss, and either the slates or schists; and I failed to observe at any point any special change in the dip, or any appearance of greater deformation than is usually seen in this section of the Appalachian system. The dip generally throughout the Goldville belt is more nearly vertical than in some other sections, but the changes in the dip at these lines of demarcation I have referred to, do not appear extraordinary, as would be the case if the gneiss strata were granite dikes, though such conditions even might be produced by shearing, which from Dr. Becker's report published recently is that authority's opinion. A study of the formations bordering this Goldville belt in the south-western direction demonstrates that these gneiss belts are continuous, and persistently maintain their places in the series in the Lower Gold belt. So that by actually following along the line of strike on either border of this gold belt I am of opinion that the gneiss will maintain its continuity longitudinally equally as persistently as do the mica schists, hornblendes or slates.

DETAILS OF GOLD OCCURRENCES.

I really took up my work of examination of the Upper

Gold belt near Almond P. O., in the south-western corner of Randolph county, where I made every effort in my power to connect, or discover a north-eastern extension, of the gold bearing lead, which is described by Dr. Phillips as maintaining its line of strike so persistently from Hillabee creek to the northern line of Tallapoosa county. But I could find no occurrence of gold-bearing ore, so far as at present known, on this belt, south-east of Malone's ferry, Sec. 11, T. 21, R. 10 E. On the

Browning property, Sec. 8, T. 21, R. 10 E., about two miles north-west of the ferry, I found the first occurence that had been prospected. This is the southernmost ore body in this formation on which any prospecting had been done on the Upper Gold belt. The shallow prospect pits exposed a low grade of gold-bearing ore, but the work, at present, is insufficient to determine the value of the occurrence, or any facts relative to permanency, or extent of the ore body.

From this point I proceeded to the old Bradford settlement, now known as the

Goldberg Mining District,

on Crooked creek, on the west side of the Tallapoosa river. This has heretofore generally been considered to be a north-eastern extension of the gold-bearing lead from Hilabee creek to Goldville in the Lower Gold belt. In being located in the same strip of semi-crystalline Talladega slate, it may be considered so still. But while lying in the same country rock, I found that the Goldville * lead proper occupies a position on the south-eastern edge of the gold-bearing formation, while the Goldberg lead occupies a position near the north-western edge of the same formation. If there should ever be established any connection along the line of strike of the ore bodies in this belt, I am of opinion that the Goldberg will be found to be continuous with Hog Mountain lead, which

* In designating these series of occurances of gold bearing ore as leads, I do not use the term with exactly the same meaning as is given to such generally in the western mining districts, but rather with the meaning as defined by Webster "a guide."—W. M. B.

also occupies the same relative geographical position in the belt. But from examination I doubt if any of these leads of gold-bearing ore continue unbroken along the line of strike for any great distance.

I should, from the indications, think that the Browning prospect might be considered an extension of the Goldville proper. To substantiate my conclusions in this respect I find that about 4 miles north of Flat Rock (Almond P. O.) several strong seams of quartz have been cut in working the wagon road known as the Wesobulga and Flat Rock road, but such are barren at this point. These veins or seams apparently persist through a prominent ridge, which is situated geographically to the north-east of the Birdsong pits near Goldville P. O., and in the same semi-crystalline slate formation, having the line of strike corresponding with that of the strata in the Lower Gold belt. The discoveries in the Goldberg district are four miles north of the general line of strike of the Goldville lead proper.

The point where the south-westernmost discovery of gold-bearing ore, on this belt in the Upper Gold region, was made is on the

Dawkin's property, S. E. ¼ Sec. 2, T. 21, R. 9 E. The work comprises some openings made prior to 1860, from which I obtained some ore; a slightly decomposed quartz. By panning I failed to get colors; although the showing of sulphurets was good, and there was some indication that a fire assay would probably show a satisfactory yield in gold.

Within the recollection of some of the oldest settlers a "pounding mill," as it was designated, was operated near the location of these old openings; and the ore mined from them, was there treated by amalgamation.

My attention was next directed to some recently dug openings or shallow prospect holes, on the crest of a ridge, on this same property. The surface of this ridge

is plentifully covered with quartz float, and ledges of quartz outcroppings, several in number, with their lines of strike parallel, and having a trend nearly north. These holes I found to be too shallow to enable me to determine the structure of the occurrences; whether they should be classed as bedded veins or as belonging to a stratified deposit.

The ore when panned yielded fair prospects in free gold. It is so far as exposed, of the character and appearance of a feldspathic quartzite, somewhat decomposed, and stained with oxide of iron. The feldspar was decomposed, and kaolin appeared as the secondary product.

The outcrops of some of these strata can be traced to, or rather appear again above the surface on the crest of another ridge, about 400 feet distant in a southerly direction. Judging from the strike these may prove to be extensions of those exposed in the old openings on this property. But such can not be determined because no work has been done to establish or demonstrate such continuity to be a fact, and the outcrops can not be traced above the surface except on the crests of the hills. The location of this plantation is near the forks, and comprises the land enclosed by White Oak and Wesobulga creeks, near, and for some half a mile above, their confluence in Clay county.

Knight's Mill, S. ½ S. E. ¼ Sec. 35, T. 20, R. 9 E.—At this point is a clearly defined line of demarcation in the formation, between the Talladega slate and bed of gneiss, having somewhat of a porphyritic character. This gneiss extends to the southward half a mile or so, but its structure conforms, both on the north-western and south-eastern edges, with that of the semi-crystalline slate country rock.

Narrow quartz veins are found imbedded in the gneiss, some of which prospect colors by panning. But such

are too thin, to ever offer any inducement for prospecting, being only from a half inch to four inches thick at the outcrop.

W. D. Mitchell's property, S. 1, T. 21, R. 9 E.—Following White Oak creek down to its confluence with Wesobulga creek on to this property, I found an occurrence of gold-bearing ore a short distance below the junction of the two creeks; in a field adjoining the Heflin and Louina dirt road on the south. Shallow prospect holes had been sunk on a ridge where a vein or seam of hard quartz, stained with iron oxides, had been exposed bedded between the strata of slate. The strike of this was slightly east of north, with its dip towards the S. E. at an angle of 35 deg. The ore panned satisfactory results in free gold; but pan tests on all the ore sin this belt, I found, after testing, to fail to give as good results as could be obtained by roasting and pan amalgamation.

I am unable to give the exact yield of any of the ores, except of a few samples assayed by Dr. J. H. Pratt for the survey; because in the field I lacked facilities for assaying the same. In making tests I am under obligations to Mr. George Camp, a veteran prospector from the West, for valuable assistance, while in this district. By the aid of a blacksmith forge, a frying pan, mercury and porcelain bowl we amalgamated samples with an exactness hardly fo be expected with such crude appliances. As we had no balances we could not determine the values of the ores except approximately, and as such estimates are liable to prove faulty, I have refrained from quoting figures. However in cases when I state that a test proved satisfactory, I am satisfied that $5.00 a ton is a conservative estimate.

It was on this same property, and in close proximity to the last occurrence mentioned, that I saw work done on another quartz seam. This exposed such a rich kidney or

pocket, as is rarely encountered. The seam of quartz outcropped on the same ridge, as the first I have mentioned, on this Mitchell property, but distant about 100 yards in a south-easterly direction. The dirt road before mentioned cross cut the quartz seam, and on the northern side of the road the cut was about 8 feet deep.

I had previously been told of a very rich pocket of ore having been discovered on this same body several years before. The discovery though had not been followed by any systematic work; and the hole that was sunk at that time it was claimed had been filled in by the road workers.

The story appeared to me to possess many of the earmarks of an Arabian Nights romance; but Bob Bradford a local prospector insisted that he believed he could, by following the dip of the vein, which is about 35 degrees towards the south-east, discover another pocket. My curiosity prompted me to witness his work.

After sinking about 4 feet below the surface of the wagon road, he was as good as his word, and took from a pocket or kidney in the quartz vein about 75 pounds of ore. This had all the characteristics of arseno-pyrite or mispickel, and when roasted showed that such was the nature of it. During the roast the arsenic and sulphur were sufficiently eliminated to set free the gold, when by stiff pan amalgamation 1¼ pounds of the ore yielded a button of gold of the value of 17 cents, or nearly $300 a ton. Future work at the same place failed to show any more such pockets, but such work only attained an increased depth of about 6 feet. The thickness of the quartz vein at the depth attained was 12 inches. It is apparently interleaved between the slates. The float as well as some outcroppings would indicate that it may persist along the strike of the formation parallel with the seam of quartz I first examined on this same property, and have already referred to. The dip of both

these quartz seams is in the direction of the gneiss rock I found interstratified with the slates, and which shows in a mass above the surface, 30 feet to the south-east of the prospect hole in which the pocket was discovered.

On the north-eastern extension of this ridge and about 200 feet from the road another prospect hole had been sunk which exposed still another vein of gold-bearing quartz, with its strike parallel to the two first mentioned, and dipping conformably with the formation, and also with the dips of the other quartz bodies. The structure of these ore bodies as well as their permanency and extent, can only be determined after more work has been done.

My own opinion is that they will continue down conformably with the stratigraphy or cleavage of the country rock, and be subject to the same folding and faulting as that has sustained.

The gravel in Wesobulga creek prospects well in placer gold, at the crossing of the Heflin and Louina dirt road.

Farrar property N. W. ¼ of S. W. ¼ Sec. 36, T. 20, R. 9 E. On this property my attention was directed to some old workings, consisting of a tunnel 50 feet long, and a deep shaft; where mining operations had been carried on before the war of '61 to '65. In the tunnel, which I explored, I found some gold-bearing quartz which prospected by panning. But I was unable to determine the extent or character of the ore body in place, because of the dangerous condition of the opening.

This was really a cross cut, having been run at right angles to the strike of the formations; from the size and appearance of the dumps, as well as condition and extent of the openings, these workings must have been quite extensive for their date. However, I could find no outcrop exposing rock in place in the vicinity of any of these old workings, although pieces of quartz float of a sugary character, stained with iron oxide, and consid-

erably decomposed were very plentiful on the surface; covering several acres.

The only recent work performed on this property which exposed the occurrence of gold-bearing quartz, was the sinking of a well in which a ledge of quartz 15 inches thick was cut near the surface. The strike of this is slightly north of east and south of west, with its dip towards the south at an angle of 25 degrees.

The slate country rock underlying this seam of quartz was mineralised, and prospected by panning as also did the quartz from the vein.

One of the legends of the neighborhood is to the effect, that in the ante-bellum days, old Mrs. Farrar used to pan in the branches which flow through this property. From the gold she obtained, the story goes, she was able to furnish herself with all the pocket money she needed, besides supplying the table with coffee, sugar and other luxuries.

W. D. Mitchell S. W. ¼ of N. W. ¼ Sec. 36, T. 20, R. 9 E. This property adjoins the Farrar tract on the north. Gold-bearing ore, very highly sulphuretted, and having the characteristics of arseno-pyrite, occurs, and a shallow prospect hole had been sunk, but the work was insufficient to enable one to determine any facts as to extent, permanency, or value of the prospect. The ore yielded satisfactory results when roasted and treated by pan amalgamation.

No outcrop was exposed on the surface, so that no idea could be formed of the occurrence, beyond the showing in the shallow pit. This class of ore I usually found nearer to water level, but in this instance it occurred on the crest of a high ridge, and close to the surface.

Dr. Manning's Property, Portions of Secs. 25 and 36, T. 20, R. 9 E.—A portion of this property forms one of the old land marks, with regard to placer diggings. These must have been worked not less than 60 years ago, for

the tailing dumps are buried under two feet of soil to-day, and trees 10 to 12 inches through have grown thereon. From all appearances placer mining must have been carried on quite extensively here in days gone by. But the deposits were not entirely worked out, because at the present time good prospects are obtained in coarse gold, from nearly any of the gravel bars in the creek beds. However these bars are not extensive, and would hardly pay to work. Most of these old diggings were on branches which empty into Crooked Creek on this property, and the section adjoining it on the south.

Gold-bearing ore bodies also occur in the quartz. From the appearance of these ore bodies at several openings on the crest and near the base of a steep ridge, I am inclined to class such as stratified deposits rather than veins, because the strata of gold-bearing rock, and decomposed mineralised slate lie conformably with the general formation, are in fact a portion of that formation, having no well defined walls.

The general line of strike is about N. 40 deg. E. but at some of the openings the folding has been so violent and extreme, that the formation has no general lines of strike and dip; but both are abnormally twisted and contorted, and point in nearly every direction. This state of facts though is only local. At one opening in particular the crest of an anticlinal curve is clearly defined. Several thin veins of quartz, very much stained with iron, but quite hard, cut the formation at right angles. These pan very richly, but are so thin, no work has been done with a view of developing them.

The richest pan tests so far obtained in this district in free gold, I got from average samples on this property. Assays made by Dr. Pratt yielded from samples taken on Sec. 36, $23.03 a ton and $10.42 a ton. These were selected at haphazard, and not from systematic sampling.

The ore in the stratified deposits from the lower strata has arseno-pyrite characteristics, carrying on excess of sulphur and arsenic; but near the surface it has become oxidised, and is of a free milling nature.

Cockrell, N. E.¼ of S. E.¼ Sec. 25, T. 20, R. 9 E.—This property joins the Manning on three sides, the north, west and south; and the waters of Crooked Creek flow through the north-east corner. Here the creek has been dammed, the water-power being utilized to run a grist mill and gin.

A short distance to the north-west of the mill, occurs the outcrop of a gold-bearing quartz seam, between slate walls, with its dip south-east on an angle of 25 deg. The hanging wall (where exposed in a shallow pit) is more vertical than the foot wall, and if such a condititiion is continuous for any considerable distance in depth, the permanency of the ore body is certainly endangered. The openings were all quite shallow, indeed so much so, that nothing beyond the occurrence of the ore between the slates could be determined. The character of the ore is the same as I have before referred to as a feldspathic quartzite. Usually on this belt where ore of this character occurs near the surface, it is replaced as depth is attained by a more or less decomposed quartz and sulphuretted ore, from which in some cases rich results are obtained, This feldspathic quartzite, which appears closely allied to mica-less *granite*, in general appearance, rarely gives more than colors, and often only sulphurets. From this last described property I crossed Crooked Creek, which here forms the boundary line between Clay and Randolph counties; leaving the first named and entering the precincts of the last.

Goldberg Mining Company, S. W.¼, Sec. 30, T. 20 R. 10 E.—From the Manning property in Sec. 36 I had followed by observation the lead of gold-bearing ore, and discovered that in a north-easterly direction, as you ascended the slope

of a ridge the float and outcrop denoted another body or an extension of the first. This ridge is continuous, except where the waters of Crooked Creek have cut a channel through it, for some considerable distance, and is locally known as the "Bradford Ridge." On this, and another parallel ridge, the company from which this district derived its name, performed prospect work in 1893.

The work done was of a more extensive nature, and more systematic than on most of the properties I had examined on this Upper Gold belt to the south-west. From it I was enabled to form a more comprehensive idea of the structure, extent, and nature of the ore body. At one point an open cut showed a thickness of pay ore 16 feet. At another a shaft sunk on an incline conformably to the dip of the formation, and with the dip at an angle of about 20 deg. towards the south-east, was in ore for a distance of 50 feet from the mouth. This showed a thickness of 6 feet of ore at the face, with ore still below the floor.

These openings were made on the Bradford ridge, a short distance north-east of Crooked Creek.

The first of these (the open cut) showed all the characteristics of a stratified deposit, composed of quartzite, slate and clay interleaved, and capped by a hard quartz. No walls enclosing this ore body could be discovered; the entire thickness prospected, and some of the strata yielded quite rich results. The dip of this deposit conformed with that of the formation in the shaft. But at the heading in this shaft the dip increased to an angle of about 45 deg.; there water interfered with further progress. The ore body at this point was more solid, and the distinction between pay ore, and country rock better defined.

From the increased angle of the dip together with this change in the ore body, I was led to believe that as

depth was attained the structure might change and assume the characteristics of a segregated or bedded vein.

This theory I found sustained by the conditions at the Franklin mine in Cherokee county, Ga., which I visited in 1893; the country rock was a mica-schist though, instead of slate. The solid formation at that mine was encountered at a depth of 115 feet. Sinking was continued on an incline shaft until it reached a depth of 425 feet, on an incline of 45 degs. From the point where the solid formation displaced the decomposed material, well defined slate walls enclosed an ore body of about 16 feet in thickness, bedded in conformity with the dip of the slate, and apparently continuing down, an undetermined depth.

Above this solid formation, I was reliably informed that the body was composed of such strata of quartzite and mineralized schist with clay as occurs on the Goldberg property, the only difference being the nature of the country rock and the angle of the dip. Besides the two openings I havementioned on the Goldberg property on the Bradford ridge, I found several others of greater or less extent,along the line of strike of the ore body. In all of these the same character of ore had been exposed, which tended to show that the body was continuous along the strike, a considerable distance. The ore, as depth was attained in the incline shaft, carried a greater percentage of sulphurets, and after roasting, prospected much richer than at the surface. While the average yield will not exceed $5.00 per ton, yet some picked samples have assayed as high as $100.00.

The following assays from this property were made for the survey by Dr. Pratt, of Birmingham, Ala., from samples taken at haphazard: $5.15, $3.14, $2.56 a ton respectively.

On a ridge parallel to and a short distance to the northwest of the Bradford ridge, and within the boundaries

of this same property, several shallow openings had been made exposing gold-bearing ore. But the work was not sufficiently extensive to enable me to determine any facts, except that from the dip of the strata of these ore bodies, if the continuity is maintained across the trough dividing the two ridges; these last mentioned strata would underlie the ore body already exposed on the Bradford ridge.

My attention was also directed to some thin true veins cross-cutting the formation, on this northerly ridge. These vary in thickness from 6 inches to 15 inches, and pan much richer than the stratified deposits. No work has been done on any of them to show what results would follow from development. The ore is a very hard quartzite, very much stained with iron oxide, and at the surface free from sulphurets.

On the north side of Crooked Creek, the gold-bearing belt appears to widen out as you follow it towards the north-east.

The Goldberg Company having determined to their satisfaction the character, and partially the extent of the ore body, talked of making preparations to perform permanent development work, and erect a plant for treating the ore. At the present time though all work by this company has been suspended.

The ore is of a refractory nature and will not yield to treatment by ordinary amalgamation. Because while the percentage of free gold is large; yet the presence of arsenic, sulphur, with sometimes traces of antimony and copper certainly place it in the refractory or rebellious list.

Bradford Fraction, Sec. 30, T. 20, R. 10 E.—This property consists of 30 acres in the extreme S. W. corner of the section, and comprises a high ridge which extends to the north-east from Crooked Creek parallel with the Bradford ridge, I have before mentioned, and distant

about half a mile to the north-west. Here I found an opening on an ore body with its line of strike nearly north-east and south-west, and dipping almost flat towards the south-east. The ore has the same appearance as the feldspathic quartzite referred to as occurring in other locations in this district. At another location on lower ground, the ore is an arseno-pyrite, somewhat resembling gray copper, but sometimes showing free gold visible to the naked eye.

These openings were not of sufficient extent at the time of my visit to enable me to form any opinion as to value, or extent.

Assays by Dr. Pratt of two samples from this property yielded $5.15 and $3.95 a ton in gold.

Bradford Ridge, N. W. ¼ of S. E. ¼. Sec. 30, T. 20, R. 10 E.—On the Bradford Ridge proper, of which the Goldberg ore body is in the south-western extension, I find more extensive prospecting work has been performed than elsewhere in the district. Several openings have been made about a quarter of a mile north-east of the Goldberg property.

The first I visited is an open cut, run into the hillside until a breast 20 feet in thickness was attained. This is composed of strata of quartzite, decomposed slate and clay; the whole mass apparently being gold-bearing, and forming a stratified ore deposit. Prof. Aughey informed me that from three picked samples representing this entire thickness, assays showed $17.75, $18.00 and $16.50 a ton in gold respectively.

From this heading I took several samples at haphazard, some of which assayed by Dr. Pratt, of Birmingham, only yielded $7.23, $7.75, and $5.15 in gold a ton respectively.

Beyond the heading of the open cut it was found advisable to tunnel, and as the work progressed the ore became harder and the body more concentrated. At one

point the strata of decomposed slate and clay disappeared, leaving a solid ore body eight feet thick. At a distance of about 50 feet from the face of the cut, the dip of the ore body becomes more inclined towards vertical; and at the heading of tunnel, 50 feet farther, it assumed an arc like shape; the ore body apparently continuing down with an almost vertical dip.

Here sinking was commenced, and had progressed to a depth of about five feet when I last saw it. The winze was in ore, but water was rising and threatened to interfere with the work unless pumping was resorted to; for which no provision had been made. The ore from this winze is highly sulphuretted and of the arseno-pyrite variety, carrying both arsenic and sulphur in combination with the gold. (The richest ore found on this ridge, so far as concerns *free gold*, is a quartzite of reddish color, very much decomposed and porous.)

The open cut and tunnel do not drift on the ore body along the line of strike, nor exactly cross cut it; but the opening has been run on an angle between the strike and dip, consequently it does not expose the true thickness of the body, and is no guide by which to estimate extent.

Other openings to the south-east of this open cut and tunnel show bodies of ore overlying or overlapping the one exposed in that opening, at irregular intervals. These are all shallow, and afford little data to base estimates on. There is one shaft which has been sunk some 50 feet. In this, one stratum of ore occurs near the bottom, and work was suspended before the entire thickness was cross cut. The shaft has not been sunk deep enough to cross cut the downward extension of the ore body exposed in the main tunnel.

The ore in all these openings bears the same general characteristics, becoming more sulphuretted towards water level. Assays yielded \$5.70, \$5.44, \$3.99, \$3.95 a ton in gold. A ten-stamp mill, fitted with stamps weigh-

ing 100 pounds each, has been run on this ore for some time by inexperienced operators. With what degree of success as to saving the gold, I could not ascertain; but from the fact that all operations have been abandoned since my examination, I am of opinion that failure resulted, as I anticipated would be the case.

A branch which flows at the south-east base of the ridge on this property has been the scene of some placer mining operations, and the gravel in its bed at places still prospects.

John Turner's Property E. ½ of S. E. ¼ of Sec. 30, T. 20, R. 10 E., N. E. ¼ of N. E. ¼ Sec. 31, T. 20, R. 10 E., also a fraction of S. E. ¼ of N. E. ¼ of Sec. 31, T. 20, R. 10 E.—I have described this property thus minutely because someoccurrences of gold bearing ore are found on each tract. The property consists chiefly of three ridges with Crooked Creek flowing between two of them; and the branch I have already referred to as on the Bradford property, forming the dividing line between the Goldberg and Turner properties, as it flows towards its confluence with Crooked Creek.

The bottoms on each side of this branch are wider between the Goldberg and Turner properties than on the Bradford. Pay gravel beds extend some little distance on both sides of this branch; but not sufficiently rich to pay for sluicing, though panning shows prospects. Crooked Creek is a bold stream with considerable fall to supply power for machinery, as it winds between the ridges, and would afford ample water for hydraulic mining besides, should investigation demonstrate the gravel bars to be of sufficient extent and value for such operations.

The ridge in Sec. 31 presents many features of interest. Although the summit is now about 100 feet above the level of the creek, yet in the far distant past, this

was evidently occupied by the stream when it flowed at a higher level, before it had cut its present channel. To-day the lines formed by the receding waters are apparent, and on the highest point *iron garnets,* or limonite pseudomorphs resulting from the decomposition of pyrite, with the edges worn entirely round, as large as 45 calibre bullets can be picked up on the surface by the handful, as well as pebbles, and gravel also water-worn into rounded shape.

The surface of this ridge prospects in places, especially in the gullies on the sides; and I am informed that some fairly large nuggets have been found in Crooked Creek, near the base of this ridge.

Some shallow prospect holes expose the occurrence of an ore body of gold bearing quartz; samples from which showed colors in the pan. But the work has not been sufficient to enable me to determine the extent or structure.

Crossing the creek, I found some prospecting had been done at the south-east side and at the base of another ridge; this is the ore I have referred to as being separated from the Goldberg property by the branch which empties into Crooked Creek, and forms the dividing line. It is located in Sec. 30, and has its trend parallel to the Bradford ridge.

The work at the base resulted in exposing some ore, carrying an excess of arsenical pyrite, which assays showed was of too low grade for profitable mining. But on the crest of this ridge several shallow openings exposed a body of gold-bearing quartz of a free milling variety, which bore many of the characteristics of the quartz found in the thin veins on the Bradford fraction. By panning I obtained good results from nearly every sample I had selected at haphazard. However, the pits were all too shallow to show more than the occurrence of the ore; except but being sunk along the line of

strike at frequent intervals, proved that ore-body was apparently continuous in that direction.

W. D. Mitchell's property, W. ½ N. E. ¼ and S. E. ¼ N. E. ¼ Sec. 30; also N. E. ¼ S. W. ¼ Sec. 19, T. 20, R. 10 E.—This has been prospected in several openings, and three distinct ore bodies exposed. One known as the *Pine Hill Mine* is located on the S. E. ¼ N. E. ¼ Sec. 30. This is apparently an extension of the ore body on the Bradford ridge, as it possesses all or nearly all the characteristics of that occurrence, with the same trend and dip; as well as structure of the ore body, and nature of the ore.

The work done in prospecting in the early spring of 1896 consists of one incline shaft about 80 feet deep, and some other pits of less depth along the line of strike; as well as a drift run at right angles to the shaft 40 feet below the surface. Some samples from this prospect quite richly; but a fair average showed it to be not over $5.00 ore. The drift has been run 100 feet and shows that the ore body is continuous. Cross cuts show its extreme thickness to be 14 feet, and its average not less than 6 feet, so far as exposed in the workings.

On the tract in Sec. 19 a vein, with its strike almost due east and west, and dip vertical, occurs. This possesses many of the characteristics of a true vein, but is only about six inches thick at the outcrop, widening though to twelve, within ten feet depth, and twenty-four at eighteen feet depth. This is as deep as it has been sunk on, which is hardly sufficient to determine what results further development will show. But sufficient to warrant its being classed as a good prospect; especially as the ore is free milling, and richer in the average yield than any in the district. Fifty feet to the north of this occurs another vein possessing the same characteristics as the first, and eighteen inches thick where exposed.

Adjoining this property on the north and north-west,

we find the extensive beds of gneiss, in which are the flat rocks (granite), known as the Blake's Ferry flat rocks, and in which no occurrences of gold-bearing ore have been discovered.

Teakle property, W. ½ N. W. ¼; N. W. ¼ S. W. ¼; S. E. ¼ N. W. ¼; Sec. 29, T. 20, R. 10 E.—This property, together with some adjoining tracts located at the confluence of Crooked Creek and the Tallapoosa River, is locally known as "Hunt's Quarters,"—deriving its name from the fact, that during the war a man named Hunt bought a number of negroes from the State of Mississippi and kept them here. A series of ridges extend across this property with their lines of strike N. E. except at a few places where folding by lateral pressure has bent the semi-crystalline slate formation from the normal line. These cases are only local, and the general trend in such instances has been resumed, a short distance, from the points where deviations occur. Several prospect holes have been sunk on two of the ridges, exposing bodies of sulphuretted ore. But such are not deep enough to furnish any data; in fact, in only one or two has rock in place been reached. Consequently these bodies present the appearance of irregularly formed pockets, or masses of arsenical-pyrite and quartz without stratification.

It is claimed that at one opening, a deep shaft, known as the "Orum Pit," which was sunk several years ago, a vein of quartz bedded in the slate was discovered. This, I was informed, was enclosed between well defined slate walls; but the condition of the shaft was such, at the timeof my first examination, that I was unable to explore it. Since then, in September, 1894, I have made a second examination because of learning that such a vein had been discovered, and opened on, to the south-west of the "Orum pit" about 600 feet; which was apparently an extension of the ore body mined in that pit. I found

good reasons for this theory, in the facts, that the last discovery is directly on the line of strike of the formation; the quartz carrying gold has the same general characteristics as that found on the dump at the mouth of the shaft; and the strata of country rock outcrop along the line of strike so that the continuity can be easily discerned.

At the present time—September 1894—an *arastra* is being run on this ore, a portion of which prospects richly enough to render this slow method of treatment profitable. But great care will have to be exercised in selecting the ore, which should be thoroughly roasted, before treat ment, in order to obtain the full values. This arastra was shut down later during the same year because the drag rocks were not heavy enough to pulverize the ore properly and work has not been resumed.

The ore is a hard, but not a flinty, quartzite, although the grain is fine. At the surface it pans richly in free gold, but a foot or two below is heavily sulphuretted. These sulphurets yield very readily to fire, and the sulphur is eliminated with less intense heat than is usually the case.

The openings are only shallow pits, and the ore body shows a thickness of about two feet at a depth of some eight or ten feet, with the incline of the dip. This is at an angle of about 20 degrees towards the south-east.

In what is known as

Wild Cat Hollow, Sec. 29, T. 20, R. 10 E., adjoining the Teakle property on the north-east, I found some prospecting work being carried on in 1893. This is a quarter of a mile west from the mouth of Crooked Creek. A body of ore resembling arseno-pyrite in appearance had been exposed at the base of a high bluff. This will only yield any value after a thorough roast, when the gold can be separated by stiff pan amalgamation. It apparently carries no free gold, and is more refractory than any other in the district. Such may be accounted for from the fact that the ore is really from a lower level than any from other prospects.

The formation here has been subjected to such extreme folding that the line of strike is locally nearly north and south, and dip to the east almost flat.

The face of this bluff is formed by strata of Talladega slate with barren quartz intercalated; and at the point where work was in progress these barren quartz seams have, subsequent to their deposition, became auriferous. So little work had been done, though, that no idea could be formed as to what conditions would be exposed by future work.

Morris property, Sec. 21, T. 20, R. 10 E.—This is located to the north-east of the Teakle property. It consists of several ridges of semi-crystalline slate formation, peculiar to the gold districts, forming a bend of the Tallapoosa River, and on the west side. The river itself crosses the north-east quarter of this section, having a north-west and south-east course.

Some shallow prospecting work has been done exposing the occurrence of gold-bearing ore. At one point a prospect shaft 18 feet deep, exposes a body of ore 14 feet in thickness, and the bottom of the shaft is still in ore. This however, has the same irregular structure, I have remarked on as occurring at other locations in this district. The outcrop of this formation can be traced to the river, about a quarter of a mile to the north-east, at which point are shoals formed by bold and prominent ledges of slate, with quartz interlaved between the strata, but no prospecting had been done to determine whether or not it was gold-bearing. These ledges of slate ean be followed for considerable distance on the east side.—In fact the formation extends to the *Alabama-Georgia boundary line*, and beyond to an undetermined distance.

The trend of this semi-crystalline slate formation here is the same as the course of the Little Tallapoosa River, N. E. and S. W., and it continues up that river to its

source in Carroll county, Ga., south-east from the Villa Rica mines.

Although in years gone by prospecting for gold has been done on this belt around Wedowee, the county seat of Randolph county, and at other localities; yet I could obtain no reliable information of the discovery of any-body of gold-bearing ore.

Most of the prospecting has been done along the N. W. edge of the belt in the vicinity of the Little Tallapoosa River. But I could learn of no location where the work had been of recent date, or of even on such a scale as in the Goldberg District. To the north of Omaha P. O. about one and a half miles, in Sec. 32, T. 19, R. 13. Mr. Joshua Ballard has prospected on a small scale, but without very encouraging results. This is on the south-east edge of the belt. The surface is plentifully covered, through that neighborhood, with limonite pseudomorphs. Some of these are quite large, and one specimen, weighing about ten pounds, when broken open was found to contain besides the pyrite, a quantity of sulphur in minute crystals, almost as fine as powdered glass.

Many stories are told, of valuable discoveries in the past, along the line of strike of this belt north-east of the Tallapoosa River below the mouth of the. Little River. But on investigation I could find but little reliable authority for such. No exposures of gold-bearing ore bodies can be found for examination; except on the property of

H. S. Bradley, Sec. 30, T. 19, R. 11 E., where a ridge, apparently formed from a conglomerate deposit, occurs. This conglomerate prospects colors, and apparently carries a large per centage of limonite. The extent of this mass is considerable, but the samples I tested, carried too small a value in gold to class it as pay ore.

There is one feature with regard to the formation of this belt, especially noticeable in the Goldberg District to

which I desire to call attention. It is the great abundance of limonite pseudomorphs after pyrite, (iron garnets) which are found imbedded in this semi-crystalline slate throughout the entire district. This is more noticeable though on the

Grizzle property, Sec. 24, Township 20, Range 9 E., where a line of demarcation between the slates and gneiss occurs. The surface is literally covered with these "garnets," some of which are very perfect specimens and quite large. At the time of my visit the lumps of slate, and slabs which are very thickly scattered over the surface; especially of one 40 acre tract, were being picked up, and piled to render plowing and cultivation easier. Nearly every piece of this slate contained several fine specimens of these garnets.

A vein of hard quartz, has been prospected a depth of 30 feet, this is bedded between decomposed slate and kaolin resulting from the decomposition of the feldspar in the gneiss. Near the surface some rich specimens, carrying free gold, were taken from this vein, which is however only 6 inches thick; but as sinking was continued the quartz carried much less value, indeed some of it, not even showing a trace of gold. At the point where this shaft was sunk the quartz appears to be interstratified with the gneiss and slate having its dip at an angle of about 45 deg. towards the S. E.

Resumé on the Goldville Belt.

I. The Goldville belt of semi-crystalline slates, from its extreme south-western boundary to the State line is nearly 90 miles in length, and of an average width of 6 miles; consequently its superficial era is nearly 540 square miles.

II. In the Upper Gold belt the prospecting has not been sufficiently extensive to warrant any definite determination as to value of occurrences of gold-bearing ore.

III. None of the openings except those on the Mitch-

ell property at Pine Hill, have been made in such a systematic manner as to enable us to figure on quantity of ore in sight, and probable permanency; or even determine definitely the structure of the ore bodies.

IV. The gold-bearing ores found on this belt in the Upper field, may be universally classed among the refractory ores, although some few exceptions may be found to that rule.

V. The prospects are good enough and sufficiently promising to warrant deeper mining in many places before any judgment should be pronounced.

VI. The gold cannot be saved by amalgamation on plates; neither will concentration after amalgamation prove perfectly satisfactory. Because the specific gravity of a percentage of fine gold found in the ore, as well as of a percentage of the sulphurets is not sufficient to prevent running water from carrying such particles away with the tailings.

VII. Direct chlorination of the ore after thorough roasting or possibly treatment with amalgamator and settler by Frazer and Chalmer's process, after roasting, may prove satisfactory, and result in profitable mining operations.

Assays as returned by Dr. J. H. Pratt of Birmingham.

Number of sample.	LOCATION.	Value in gold @ \$20.67 per oz.	Value in silver @ 75cts. per oz	Total value per ton 2,000 lbs.
1987	Goldberg, Sec. 30, T. 20, R. 10	5.15	....	5.15
1988	" " "	3.14	....	3.14
1989	" " "	2.56	....	2.56
1990	Jno. Turner, " "	4.59	08	4.67
1980	Bradford Fraction, Sec. 30, T. 20, R. 10	5.15	08	5.23
1981	" Ridge " " "	5.15	....	5.15
1982	" " " " "	5.70	15	5.85
1983	" " " " "	5.44	22	5.66
1984	" " " " "	3.99	....	3.99
1985	" Fraction " " "	3.95	....	3.95
....	W. B. Mitchell, Sec. 1, T. 21, R. 9	9.81	....	9.81
....	Dr. Manning, Sec. 36, T. 20, R. 9	23.03	....	23.03
....	" " " " "	10.42	....	10.42
....	J. Walker, Sec. 29, T. 20, R. 10	5 37	....	5.37
....	Teakle, " " "	6.20	....	6.20
....	Bradford Ridge, Sec. 30, T. 20, R. 10	7.23	....	7.23
....	" " " "	7.75	....	7.75
2052	Teakle, Sec. 29, T. 20, R. 10	3.10	....	3.10

These assays were made on samples selected at haphazard, but with a view to obtain as near an average as possible, without sampling by the systematic quartering method; for which no facilities were afforded the survey.

MICA SCHIST GOLD BELT.

Location and General Characteristics.

Leaving the Goldville belt of semi-crystalline slate to the south-east, we cross the line of demarcation and into a region of gneiss and mica schist, which extends towards the north-west as far as the south-eastern foothills of the Talladega mountains. This region embraces an area of about 1,000 square miles, and comprises within its boundaries, portions of Coosa, Tallapoosa, Clay, Randolph and Cleburne counties.

This belt also contains two distinct leads of gold-bearing ore, so far as at present known. These may be designated as the Shinbone Ridge or Kemp Mountain lead, and the Pinetucky lead.

As the last named occurs to the south-east of the first my examination was resumed on that, after finishing my work on the Goldville belt.

With regard to this mica-schist formation, I found that it did not reach as far as the Alabama-Georgia boundary line. Its north-east extremity being Sec. 24, T. 17, R. 12, about 2 miles west of this boundary line. Here it terminates somewhat in the form of the narrow edge of a wedge, and is interstratified with the semi-crystalline slates in apparent conformity. Towards the south-west it widens out and attains its extreme width in the neighborhood of Pinetucky, in the north-western corner of Randolph county, where it is nearly 18 miles wide; extending from Rockdale, Randolph county, near the centre of T. 19, R. 11 E. to Chulafinnee, Cleburne county, Sec. 13, T. 17, R. 9 E.

Details of the Gold Occurrences.

Pinetucky Gold Mine, Sec. 12, T. 18, R. 10 E.—The

discovery of gold-bearing ore here was one of the earliest in Alabama, being co-temporary with the Arbacoochee Placer discoveries in the "forties." Some mining operations of a very crude character were carried on here about the same time that Arbacoochee was a prosperous typical mining camp. A volume of interesting reading could be written devoted exclusively to the early days of Pinetucky. Its changes of ownership have been numerous. Changes in the policy of the owners equally so. But up to the present time so far as I can ascertain from reliable sources, the results have invariably been partial or total failures. The blame rests to a very great extent on the shoulders of the management and owners, but not entirely so. Pinetucky is an example of what ought to be termed a rich specimen mine. The ore carrying gold is a narrow vein of hard bluish quartz, between equally hard mica schist walls. Both the gangue rock and ore are very tough and difficult to mine. The pay streak will average about 10 inches at the present depth of the workings about 60 feet vertically from the surface. Consequently the expense for mining under the most favorable circumstances, is in excess of what it otherwise would be. Add to this the fact that the vein is of lenticular or kidney structure, and the pay ore is found in chutes or chimneys, and the reasons for failures are quite intelligible, especially when the work is conducted by inexperienced miners, and mill men; as it generally has been. This mine presents some features I have not found existing elsewhere in Alabama.

The ore body, and formation have locally an abnormal line of strike; being nearly N. and S. with the dip to the east on a very slight incline not exceeding 10 deg. or 12 deg.*

Along the line of strike on the surface this ore body can be traced for a distance of about 1½ miles by the

*Subsequent careful observations of this ore-body, at a point very favorable for getting the correct dip and strike. show that the strike is N, 30 deg. E. and the dip is towards the S. E. W. M. B.

abandoned pits sunk in the past. The pits were sunk on the outcrop, and incline down with the dip of the ore body; the free milling or oxidized ore was mined out to water level then the pit abandoned, and a new opening made at the outcrop, to be mined out in the same manner, and in its turn abandoned. On the north and south granite veins outcrop with their lines of strike conforming to the general formation of the country N. E.—or only varying a few degrees from such a course. These veins carry mica in crystals of sufficient size to dress into sheets of commercial value.

As the vein of gold-bearing ore varies in thickness from a streak not much thicker than a knife blade, to 14 inches and sometimes exceeding that; so does it vary in richness from a mere trace of gold to the ton to $150.00 a ton. The values saved in the mill runs, in the ten stamp Fraser and Chalmers Mill erected some 5 or 6 years since, vary in much the same proportion as the assay values. One lessee claims to have saved $40.00 a ton from the ore, and $7.00 a ton from some runs on hanging wall rock. Another, that 100 tons of ore only yielded a total amount of $38.00 after costing $1,500.00 to mine. I have seen many specimens of the ore showing free gold in great splotches, and at one time I saw nearly 2 tons of ore mined nearly every piece of which was a fine cabinet specimen. I know myself of mill runs having been made which yielded $40.00 to the ton in free gold, but were limited to less than 4 tons to the run prior to a clean up.

A great deal of value has always been claimed to be carried by the sulphurets, with which the ore is heavily charged. It is impossible, however, at present to verify such a statement, because really no thorough system of concentration has ever been carried on.

Some concentrates sent to St. Louis in 1893 yielded according to Prof. Potter's assay $666.00 a ton in gold;

while other samples taken about the same time and presumably from the same pile only yielded $90.00 a ton, according to assay made by Mr. Makemson, Chemist for the Woodstock Iron Company, at Anniston. Some other samples sent to New York, a few weeks later, only assayed from $8.00 to $28.00 a ton, as returned by an assayer, for a new process for saving gold from concentrates called the "Kendall" process. Duplicates of these last were also sent to St. Louis, and the returns were approximately the same. Such results demonstrate that a very unsatisfactory method of concentration was practiced, or else that the samples were manipulated by some interested parties.

The workings in the mine to the east of the line of pits I have already referred to, consist of a vertical shaft 55 feet deep, and a drift on that level about 200 feet in length. Above this the ore has been mined out from the outcrop down; no attempt having been made to work ahead on the ore body and stope up. An incline some 10 feet in depth has been run with the dip of the vein from the bottom of this shaft, and this really represents the increase in depth in the workings for the past 20 years. In taking out ore about 6 to 8 feet of the hanging wall has always been mined out, and the pay ore streak is consequently at the floor of the drift, and almost invariably, even when mining was going on under water.

This system of mining is so crude, and unskilful, that there is no chance to estimate on ore in sight, because there is none. Had sinking been continued in a shaft located in the mill house, about 200 feet to the east of the shaft I have already described, until the ore body was cross cut, the conditions would have been very favorable for estimating the value of the property. This work would have opened up at least 200 feet of virgin ground, and reduced the cost of mining very appreciably;

by affording a chance to stope up instead of digging down for the ore, besides hoisting it directly into the mill over head, instead of using a steer and whim to hoist with, and a team to haul to the mill. The steam hoist being afterwards brought into requisition to place the ore on the rock breaker floor.

During the summer of 1895, and since my examination reported in the preceding pages was written, further prospecting work was performed at the Pinetucky Mine. This work was done with the aid of a diamond drill. The shaft in the mill house was bored to a depth of 205 feet without cross cutting any ore body. The cores from the drill showed granite at a depth of 55 feet, alternating with the garnetiferous mica schist country rock to the depth of 205 feet where work was abandoned.

A second drill hole was bored about 70 feet to the west of the mill house, and on a line between that and the old workings. In this mica schist was passed through to a depth of 60 feet, when granite was encountered, and to a depth of 130 feet the same conditions were found to occur as in the mill house. At this point work was abandoned, and a third hole sunk to the west. This hole is 80 feet east of the old working shaft. At a depth of 47 feet after passing through mica schist, the core showed granite was encountered. At a depth of 47 feet a 4 inch stratum of feldspar was passed through, and below that the core was ore, of much the same character as in the old workings. This, I am informed, was 12 inches thick. Next was four feet of soft gouge material, which was lost from the core, because of its softness. Below this a garnetiferous mica schist, similar to the country rock occurring in the old workings, was encountered for a few feet, and below that granite again showed in the core.

The Pinetuckey Company executed a lease to the Fair Mining and Milling Company, of Chicago, to extend over a period of five years. The lessees performed the

prospecting work with diamond drills, and after encountering the ore body in the third hole, commenced the work of sinking a working shaft at that point. This work is being carried on with dispatch. It is purposed to drift both to the north and south after cross cutting the ore body. Stopes will then be started, and the ore mined out to the old workings about 80 feet above, on the incline of the dip of the ore body.

I am informed by Mr. Hugh McIndoo, of Chicago, one of the lessees, that a thorough sampling of the mine in the old workings had been made prior to the prospecting with diamond drill. The assays showed an average yield of $38.00 per ton. Further tests showed that the ore was partially free milling. Some to the extent of 25 per cent., and others to 75 per cent. With regard to concentrating, I was informed by the same authority that such would result in the proportion of one ton of concentrates being obtained from 216 tons of ore.

No well defined extensions have been discovered, of this ore body, unless a discovery in a well on Sec. 13, T. 18, R. 10 E. should prove to be such. But no effort to demonstrate such a fact has been made; although the well was sunk early in 1893 by a negro, who showed quartz resembling Pinetucky ore, which he claimed he took out from the bottom of the well.

About two miles to the north of Pinetucky, the same country rock, underlying the granite veins, and conforming with their strike and dip, has been encountered; but no gold-bearing ore discovered.

To the south-west of Pinetucky on Sec. 13 the formation resumes its normal line of strike, as it also does a short distance N. E. of the workings; indeed such change occurs on the north half of Sec. 12, the gold mine being in south half of the same section.

So far as I am able to judge from the work performed, this is the most promising portion of Alabama for min-

ing for mica. Because in several locations to be described later in this report the crystals of mica are found of sufficient size and grade to warrant the assumption that profitable results would follow systematic and deep mining.

In a north-easterly direction from Pinetucky we find a break in the mica-schist formation, where the semi-crystalline slates appear in a wedge-like shape, with the thin edge towards the south-west. The line of demarcation on the southern boundary of this semi-crystalline is about 3 miles northward from Pinetuckey in T. 17, and the point of this wedge is in the same township near the Riddle's Bridge crossing of the Tallapoosa River in R. 10 E. being the same range as that on which Pinetucky is located. The northern or north-western boundary of this wedge of semi-crystalline formation, has a north-eastern course from the river to Sec. 17, T. 17, R. 11. Here the mica-schist again occurs; in its turn assuming a wedge-like shape with the thin edge at this north-eastern point, and widening out towards the south-west. At the Riddle's Bridge a junction is formed with the main body of mica-schist which formation continues to the south-west in an uninterrupted belt.

These complications of the formation are shown in a general way on the geological map of the State, where distinction is made, however, merely between the feebly crystalline Talladega slates, and the fully crystalline schists.

I will here continue my report on the occurrences of gold-bearing ore belonging to the north-westerly belt of mica, and hornblende schists of the upper gold belt and consider those belonging to the semi-crystalline slates later in order to avoid complications.

Crossing the Tallapoosa River from Pinetucky, in a westerly direction, I found that the Shinbone Ridge, which is a continuation on the western side of the river of that chain of ridges in which is located the Kemp Mountain which forms such a prominent feature of the landscape on the eastern side of the river, with its trend to the north-east towards Turkey Heaven Mountain.

This Shinbone Ridge with its trend south-westerly, crosses a portion of Cleburne county and Clay county. It bears much the same relation to that region as the "Devil's Backbone" bears to the lower gold belt. The geology though, of these two ridges is entirely dissimilar, for while the "Devil's Backbone" is made up almost entirely of semi-crystalline slates and hydro-mica schists, the formation of the Shinbone Ridge belongs to mica and hornblendic schists. For several miles this chain of ridges occupies an almost parallel position to the Blue Ridge Mountains proper, and near the south-western extremity the trend of both the mountains and the chain of ridges is in a southerly direction. The occurrence, of gold-bearing ore, which have been discovered in the belt of mica-schists, are located in what is known as the Idaho mining district, which embraces a large portion of T. 19 and 20, in R. 7 E.

The Idaho Mining District.

This district comprises several prospects, prominent among which are the Idaho, or Franklin, the Hobbs, the Laurel, the Chincapina, the California, and the Horn's Peak; on all of which mining operations of greater or less extent have been carried on.

The ore bodies in this district occur in the ridges, which make up the chain locally designated as the Delta Divide, which in this locality really embraces a mountainous district covering quite an extensive area, and

comprising several ridges or backbones lying almost parallel to each other; the most prominent being Shinbone Ridge. This belt of mica and hornblendic schists in which the gold-bearing ore bodies occur, is bounded on the north-west by a belt of altered eruptive rocks, locally termed "the copper lead," because iron pyrite, associated with chalco-pyrite has been found to occur in this rock, and mining work was carried on some years since in this locality.

The entire width of the gold bearing district which I refer to as "the Idaho District" is about three miles, and its length so far as, at present known about the same. On the north-western boundary is located a property known as the "Watts" which, in days gone by, is credited with having furnished a large amount of placer gold, and is particularly noticeable because of the vast quantities of large and well shaped garnets. So vast are the quantities of these that a portion of the property itself, is known as "Garnet Hill." Near this is a branch or small stream locally known as Gold Branch, which, history says, produced a large quantity of placer gold in the seventies. Another feature of the district is that in nearly all of the valleys formed by the creeks and branches, there occur beds of gravel at various depths below the surface which will nearly always yield placer gold from pannings. This fact has been demonstrated in several localities in this district by the cutting of ditches to drain the bottom lands.

The Idaho or Franklin, Sec. 3, T. 20, R. 7 E.—A ten stamp mill was run on the ore from this mine for several months a few years since; but work was abandoned because of litigation, and the mill and mine have remained idle since 1889, but will be started up in the near future, the litigation having been decided in 1895. The mine itself is on a ridge, locally known as "Gold Hill," which might be termed a foot hill of

the Shinbone ridge, on its north-western side. Open cuts made into the side hill expose an immense mass or deposit of quartzite and micaceous graphitic schist with decomposed material resembling wad interstratified, with the strata almost vertical. The strata are very thin usually, and so intermixed that it is very difficult to obtain samples of each material separate, so as to ascertain which carries the most value. The entire mass has been quarried, and I am informed was milled without any effort to separate the products of these strata. It is difficult to form any estimate of the extent or permanency of the ore body, because the work of mining was carried on without sufficient regard to future development. Apparently the strata continue on down indefinitely, and have been mined 50 feet wide. From the summit of the ridge to the floor of the cut at its lowest depth is probably 50 or 60 feet; and a shaft was sunk in the floor of the cut several feet. But as this was full of water I could not investigate the results obtained.

A very noticeable feature about the ore body is the immense quantity of iron-alumina garnets in the gangue. In fact the occurrence of these garnets associated more or less closely with the gold bearing ores of this district, is one of its distinguishing features. Such garnets do not carry any values, so far as can be determined by panning tests, but a test by fire assay might perhaps show the presence of some gold.

The formation at the Idaho mine is nearly east and west and the line of strike is maintained for two or three miles westerly. There are at least two distinct ore bodies on this property. The most extensive being that which I have just described with another but smaller body known as the "Little Sampson" vein; apparently entirely distinct from the main body, occurs on the north-west side, and a great change is noticeable in the character of the ore which carries values. For here the quartzite itself is

auriferous, and not the schist as is the case in the big or main ore body.

The work which was performed at the Idaho mine in 1888, resulted as I am reliably informed quite satisfactorily. I have during the spring of 1896, had a better opportunity to examine this property more closely than was afforded me during the summer of 1893-4, when most of my examinations on the upper gold belt were made.

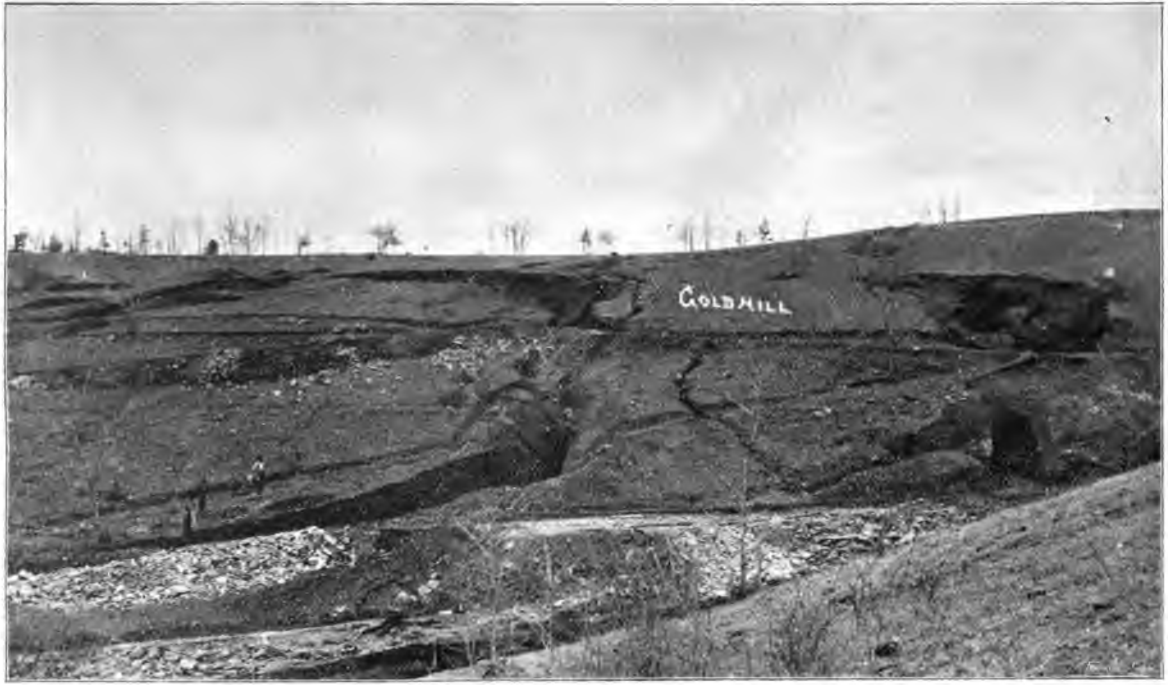
Although of course the workings have caved in to a great extent consequent upon their being large open cuts and the number of years the mine has remained idle, yet I was afforded such an opportunity under the guidance of Mr. Joshua Franklin, superintendent of the property, as allowed me to inform myself more thoroughly relative to the extent and promise of permanency of these bodies.

The open cuts extend for 104 yards along the line of strike, and show that the ore body, where these cuts cross it, is at least fifty feet in thickness.* From pannings on an average of the entire ore body, in one cut, there is certainly a value of $2.00 a ton in free gold.

This value is more closely associated with the decomposed schist than with the bodies of quartzite, which have been exposed in the mine workings, but while this is the case, it is also a noticeable fact that the schist does not yield values except where closely associated with quartzite. Whether the garnets which occur as gangue yield any values, or not, is an open question.

Some of the quartz bodies exposed in the main cut are fillers of fissure veins, cross-cutting the cleavage of the schists almost at right angles, and apparently maintaining continuity as greater depths would be attained. The dip of these is almost vertical, and the thickness has increased perceptibly at the floor of the cut, from the thickness at the outcrop, forty feet above. Mr. Frank-

* The accompanying plates illustrate the formation and structure of this occurrence of gold bearing ore. Plate No. I illustrates all the open cuts made into Gold Hill; the Stonewall cut, on the right, the Franklin in the centre and Nelson on the left. Plate No. II illustrates the Stonewall cut, showing the breast of the ore body with mouth of cross cut tunnel driven on a level with the floor of the cut. Plate No. III illustrates the Franklin cut showing conditions some what similar to those in Plate No. II.—W. M. B.



NELSON CUT FRANKLIN CUT STONEWALL CUT

IDAHO MINE

STONEWALL CUT, IDAHO MINE

lin, however, informed me that these quartz bodies carry but very little value, and indeed he did not consider such rich enough to run through the mill when he was working the property.

The second ore body on this property outcrops a distance of fifty yards north-west of the main workings. This is referred to earlier and designated as the "Little Sampson vein," and has been partially prospected, but the work has not been sufficiently extensive to warrant the expression of any opinion as to the material facts.

Judging from the line of strike of these ore bodies, a theory is tenable that if the continuity of each is maintained towards the other, the two bodies will intersect each other; because the line of strike of the main body is nearly due east, while that of the "Little Sampson" is several degrees north of east.

At the time of my recent visit, Mr. Franklin was making arrangements to resume active operations at the mine, and has been considering the advisability of adding a Huntington mill to the present plant, which is a ten stamp quartz mill. By doing this he expects to obtain relief from some unsatisfactory results he experienced before in treating the soft ore, which has such a clayey nature that in the stamp mill it chokes the screens and interferes materially with the crushing capacity, as well as with amalgamation, when quick silver is fed into the battery.

It is highly probable that this new plant will be running on the Idaho ore before the first of July, 1896; and the owners propose, as I am informed, to operate the property as a permanent investment, and with the expectation of developing it into a dividend paying mine.

Following this ridge to the south-west from the Franklin mine, I found its surface was thickly covered with pieces of quarzite, in which are embedded masses of gar-

nets, as well as pieces of limonite, closely resembling gossan. This is characteristic of the mica-schist belt, and proved an incentive in years gone by to encourage many men to prospect quite extensively for copper ore; but in this section almost invariably without success.

The Laurel, Sec. 4, T. 20, R. 7.—The ore body exposed by shallow prospect holes on this property is apparently an extension of the Little Sampson. The line of strike though is nearly east, with the dip almost vertical, and the ridge on which this is located is an extension of the Franklin or Idaho ridge. Its continuity, though, has been interrupted by some small creeks or branches which have cut channels through it as they flowed towards Talladega Creek, into which they empty.

The character of the ore is very similar to that found in the Little Sampson; the values being found almost entirely confined to the quartzite, which can be more easily separated from the decomposed matter resembling wad and schists, than at the Idaho. Samples taken from the entire mass pan very satisfactorily; and during the summer of 1893 a miner named Stevens made fair wages sluicing the vein stone from the Laurel without first crushing it,—proving by that result that the gold is disseminated through all the material forming the vein stone of the pay streak, which is about four or five feet wide.

Work on this property has been insufficient to determine any facts, beyond showing it to be a good prospect. Mr. Steed, the owner of the Laurel, informed me he proposed, during the present year, to prospect that ore body at depth, by a cross-cut tunnel, which can be easily run from the base of the ridge so as to intersect the ore body at a depth of 50 or 60 feet below its outcrop.

A stream flowing near the base of this ridge, and having its source in the ridge, will furnish ample water for mining and milling purposes. Also for hydraulic min-

ing should the gravel bars along its bed prove of sufficient extent and value. These have been worked by sluicing, at irregular intervals, for some years past, and in spots are quite rich.

The Chinca-Pina, Sec. 33, T. 19., R. 7 E.—This prospect is located on a ridge to the north of that on which the Laurel and Idaho occur. The line of strike of the ore body is North-east with its dip towards the S. E. at an angle of about 30 degrees. The workings consist of an open cut, crossing the formation ; an incline pit or shallow shaft, and several shallow holes in which the surface soil pans very satisfactorily. These last, though, have not been sunk deep enough to expose rock in place.

The openings have been made in such a manner that no reliable estimate as to value, or permanency, or extent of the ore body can be formed. The ore is found in strata bedded conformably with the formation, having no well defined walls. The pay is disseminated through these strata in the same manner, as in the more vertical strata on the Idaho and Laurel.

Hobbs, Sec. 3, T. 20, R. 7 E.—This ore body is located on a ridge extending almost parallel to but between the ridges on which occur the Chinca-Pina and Laurel. It has been exposed in several shallow pits, and is apparently a promising prospect.

California, Sec. 15, T. 20, R. 7 E.—On this property a ten stamp mill was erected some years since. and mining and milling operations conducted. But the openings were all caved in at the time of my visit, and I was unable to explore them. Beyond the fact that the ore found in the mill, and around the old dumps, yielded prospects by panning, nothing further can be said about the property.

The Horn's Peak, Sec. 4, T. 20, R. 7 E.—During the

summers of 1893 and 1894, when I made my first examination of this district, this ore body had been but very imperfectly prospected at the summit of the peak or hill from which the mine takes its name. But at this writing , spring of 1896, a recent visit to this district, has enabled me to examine the property more thoroughly, because a considerable amount of work has just been performed and several tons of ore milled in a small five stamp mill located in the vicinity.

While this peak is really a continuation of the ridge in which occurs the ore body in the Idaho mine; it is separated from the main ridge by erosion. This ore body is located almost westerly from the Idaho mine and not quite a mile distant.

A cross-cut tunnel has been run to intersect the ore body at a vertical depth of about twenty-five feet from the summit of the peak. This work has demonstrated that the ore body is some thirty feet in thickness and several runs of a limited quantity of average ore through the mill have resulted, I am informed, in a saving of $2.00 gold per ton, by amalgamation. The ore may be styled as a garnitiferous quartzite, because of the large quantities of iron-alumina garnits embedded therein.

No work to determine the continuity of this ore body along its line of strike other than shallow prospect holes along the summit of the peak, has been yet performed. Nor has any deep work been attempted.

From the structure of the peak it would have been very easy to determine the permanency and extent of this ore body at depth of about 200 feet, by merely running a cross-cut tunnel to the ore body, and drifting along the line of the strike. Such work would be doubly advantageous too, because it would have drained the mine as well as have afforded a splendid opportunity to mine the ore by stoping. The value of the property too, would have been demonstrated beyond cavil, because it would have been

an easy task to measure the quantity of ore in sight and make calculations on which the value of the property should be based.

Kemp Mountain District.

Eckles, Sec. 23, T. 17, R. 10 E.—No other discovery of gold-bearing ore has been made to the north-east of the Idaho District in the mica-schist formation on the west side of the Tallapoosa River, so far as I was able to ascertain, either by prospecting or from reliable information. After crossing the river towards the east I found prospects in many of the branches and creeks, especially on the Denman and Morrison plantations to the west of the Eckles property. But no work of any extent exposing pay ore had been done.

The Eckles property has created quite an excitement from time to time since its discovery in the spring of 1893. It was bonded during that summer for $30,000. The 40 acre tract of land on which it is located was purchased by an old prospector named Eckels for $125.00, after he had done some prospecting, the result of which was not generally known. The same tract had been offered previous to that time for a Texas pony worth about $40.00.

The prospect work consists of an open cut, crossing the formation, with a shaft some 65 feet in depth, below the floor of the cross-cut, which is about 8 feet deep. This cross-cut is nearly 50 feet in length and exposes the ore body almost that entire distance. In structure this ore body bears great similarity to those in the Idaho District; being a series of thin vertical strata of quartzite and decomposed schists, so closely interfoliated that it is difficult to obtain samples to determine which strata carry the pay. Samples taken from nearly any portion of the cross cut will yield good results without crushing

the vein stone. In sinking the shaft the strata were found to maintain their vertical dip to a depth of 36 feet, here the dip changed to an angle of about 60 deg. towards the south.

A cross cut run at the bottom of the shaft showed the ore body which yielded pay, had narrowed down to 18 feet in thickness, much of the decomposed material found at the surface having apparently pinched out, leaving the strata of quartzite more concentrated. During the summer of 1894, sinking was continued on the shaft until a depth of nearly 100 feet had been attained, without any material change having occurred in the ore body.

The surface has been prospected across the 40 acres on the line of strike of the ore body, which is slightly north of east, and its continuity demonstrated. The same results were obtained on the extreme western border of the tract, but beyond this the formation has been folded several degrees to the north; and although continuous, does not yield pay where some shallow prospecting has been done on the adjoining tract.

No systematic work of treating this ore has been done, by which an average value from mill runs can be estimated. The graphite interferes with treatment by ordinary amalgamation, and the absence of sufficient water prevents working the property by hydraulic process, and afterwards milling the quartzite tailings, as is done at Dahlonega, Ga., on a somewhat similar formation.

Such a method of mining and treatment could be carried on profitably to a depth at any rate of about 40 feet; but below that the vein stone becomes very much more solid and will probably become sulphuretted near water level.

Golden Eagle, Sec. 17, T. 17, R. 11 E.—This property was originally known as the old Price mine, and pros-

pecting work consisting of two incline shafts, one about 30 feet, the other shallower, together with about 100 feet of tunneling was performed in 1893. This work was done by some parties who held an option on the property, which however expired before any very satisfactory discoveries were made. Since then and during the spring and summer of 1894, work has been resumed by W. D. Vaughn of Heflin. Under his management an upraise was made from the tunnel to the bottom of the deepest incline shaft, and a drift some 30 feet long was run on a level with the point in this shaft (32 feet from the surface) where work was discontinued in 1893. From the discoveries made by a prospector in the spring of 1894, the first miners had quit work on the eve of exposing some very rich ore. As much of this carried free gold, visible to the naked eye, and assayed as high as $58.00 a ton, Mr. Vaughn took an option on the property and went to work at once to develop it further. He is also erecting a small stamp mill for the purpose of prospecting and sampling, that portion of the ore body which is free milling. Such is apparently the character of the ore to a depth of about 30 feet, but below that depth it can only be considered partially so because the ore is not only very highly sulphuretted, but also has the appearance which denotes that it carries a large per centage of arsenical pyrite. The deep shaft is now about 75 feet in depth, sunk on the ore body with the same incline as the dip; an angle of 50 deg. towards the south-east. The line of strike is N. E.

The vein matter consisting of quartzite and hydro mica schist is about 10 feet thick at the 75 foot level. This vein of quartzite is very much decomposed, and enclosed between what appear to be semi-crystalline slate walls, being the same character of slate as forms Turkey Heaven Mountain, which are not well defined near the surface. This occurrence of gold bearing quartzite is

almost at the extreme point of the strip of mica schist formation, which forms the northern prong of fully crystalline rocks in Cleburne county. A vein of coarse grained granite is also exposed in this formation, about 50 feet south-east of the ore body I have referred to, and which should be designated as the "lower" body, because on the south-east side of the granite vein another, and distinct ore body has been exposed. This outcrop occurs paralleling the vein of granite, which is about 30 feet thick, and in apparent conformity with the general formation, both with regard to strike and dip. In fact the series occur on the surface as follows: On the north-west, the "lower" ore body, about 5 feet thick at the surface, bedded in slate much decomposed near the surface; next in order, towards the south-east, Turkey Heaven Mountain slate 50 feet; next granite vein about 30 feet in thickness, then the mica schist in which is bedded the "upper" ore body. In this ore body the gold is carried by a sandy, sugary, friable quartzite; and considering that in 18 feet, (the depth of the incline), this ore body has increased in thickness from 6 inches at the outcrop, to 2 feet at the bottom of the shaft, it is certainly a promising prospect.

In the tunnel on this property, beyond to the south-east of the point where the "lower" ore body is cross cut, an upraise was commenced by the miners who first drove this adit. In this I find that the formation above the ore body is a pyritiferous graphitic slate very hard and similar to the slate forming Turkey Heaven Mountain it is very tough on this level, which is 50 feet vertically below the mouth of the incline shaft.

The granite vein referred to apparently is intrusive, because at a point about 300 yards from the mine workings, and to the north-east we find it is only 3 feet thick at its outcrops, which resembles a big boulder, but is continuous towards the south-west; though apparently

not so to the north-east, so far as the surface indications show.

The slate country rock which forms the hanging wall of the "lower" ore body belongs to the Turkey Heaven Mountain series, but that forming the foot walling has more the appearance of a hydro-mica schist, than the typical "Talladega" or semi-crystalline slate, found covering such an extensive area north-west of the Arbacoochee Gold Mining district, and extending to the south-eastern border of the Paleozoic area.

Traveling in a northerly course from the "Golden Eagle" or "Price" mine we find this hydro-mica schist extends for about 1½ miles. Beyond that point and northerly the geology is difficult to determine, because the surface of the ground is covered by pieces of quartz and soil with no exposures of the slate, until the north-east corner of section 9, township 17, range 11 E. is reached, where a narrow strip of hornblendic rock (diorite) occurs. Beyond this again in a northerly direction we find no exposures of the slates until after crossing the Arbacoochee and Bowden wagon road near the western boundary of section 34, T. 16, R. 11 E. where the typical "Talladega" slate occur.

**Results of Assays by Dr. J. H. Pratt of Birmingham, Ala., from samples taken at haphazard along the Mica-Schist Gold Belt.*

2053 Chinea Pina, Sec. 33, T. 19, R. 7 E. $1.38 per ton gold.
2062 Pinetucky, Sec. 12, T. 18, R. 10 E. $89.91 per ton gold.
2063 Geo. Hobbs, Sec. 3, T. 20, R. 7 E. $4.55 per ton gold.
*2064 Price "lower" body, Sec. 17, T. 17, R. 11 E. $2.75 per ton gold.
*2065 Price "upper" body, Sec. 17, T. 17, R. 11 E. $2.07 per ton gold.
2070 Laurel, Sec. 4, T. 20, R. 7 E. $77.10 per ton gold.
2004 Franklin, Sec. 3, T. 20, R. 7 E. $14.26 per ton gold.
1978 Eckles, Sec, 23, T. 17, R. 10 E. $8 58 per ton gold.

*Taken from old workings previous to resumption and new work.

"TURKEY HEAVEN MOUNTAIN" OR NORTH-WESTERN SEMI-CRYSTALLINE SLATE BELT.

Gold Ridge Mining District.

This district is located in T. 17 and 18, R. 12 E. apparently in the semi-crystalline slate formation, near the line of demarcation between the mica schist belt and the slates. In fact it is immediately to the south and east of the point where the mica schist wedges out, two miles from the Alabama-Georgia line in Cleburne county to which I have before referred.

In some respects the occurrences of gold bearing ore in this district may be considered properly to belong to the Goldville Belt; for although the formation is composed more extensively of the slates found in Turkey Heaven Mountain, a graphitic variety of semi-crystalline slate interstratified with the regular semi-crystalline varieties, than is found elsewhere on that belt; yet it is really the same, when the formations are only classed as crystalline and semi-crystalline.

I can not identify the ore bodies on their lines of strike with any in the same formation to the south-west, and for that reason as well as because of the slight difference in the country rock, I have considered this district as distinct from the Goldville Belt. So far as at present prospected the quartz seams in this district rarely carry any values. The ore which yields value is a ferruginous sandstone, but several very fine specimens of sugary quartz, impregnated with free gold are reported to have been found in this district, a few years ago. Several of these I was shown by Mr. Charles Harper of Rome, Ga., who is a part owner in about 1,600 acres of land in the neighborhood. The only prospecting work of which I could

obtain any knowledge has been done on this property, which comprises portions of Secs. 27, 33, 34, T. 17, R. 12 E. and Secs. 3, 4, 5, 7, 8, T. 18, R. 12 E.

I could not ascertain the exact location of this prospect work by section number, nor could I, when I examined it, determine any essential points relative to the ore body. A shallow incline shaft had been sunk exposing a body of ferruginous sandstone about 20 feet in thickness, having its line of strike nearly Northeast and dip about 45 deg. to the S. E. Samples taken from the dump panned in free gold satisfactorily, showing some $4.00 or $5.00 a ton; but the ore body itself could not be sampled because of water filling the shaft. I was informed that the entire thickness averaged as well as the samples I tested. It is claimed, work was abandoned because of the water rising in the shaft, and the owners were not in position to provide pumping facilities. Really the property was purchased for speculative purposes, and the only object of the owners appears to have been to expose an ore body, and make no attempt to develop it.

The property was purchased with the view of controlling as much as possible of the lead longitudinally, and, if development should prove that continuity along the line of strike is maintained, together with values, and continuity at depth, then this will be a valuable property. But such can only be determined by actual work, which at present has not been performed.

An analysis by Dr. Pratt showed $4.82 a ton in gold from samples taken from the dump I have referred to.

Turkey Heaven District.

From the Gold Ridge property I followed the line of demarcation between the semi-crystalline slate and mica schist towards the south-west, to the point where the

slates wedge out near Riddles' Bridge, and prospected back to the north-east in the semi-crystalline formation. In this region are located the Turkey Heaven Mountains, from which the mining district derives its name.

I found that gold bearing ore occurred at several locations at and near the base of these mountains, but none has yet been discovered in the mountain itself. On its summit and sides, as well as in the formation to the south-west, the graphitic variety is interstratified with the Talladega, and other semi-crystalline slates, and all of the occurrences of ore carry a large percentage of this graphite.

Miller, Sec. 35, T. 17, R. 10.—This is the most south-westerly discovery of gold bearing ore in this Turkey Heaven District. It is located only a short distance from the point where the slates wedge out, and are displaced by mica schist.

A few shallow prospect holes have been sunk, and a body of sandstone exposed, a portion of which carries gold. This ore is found to occur under a limonite capping, and I could find no evidences of well defined walls to indicate vein structure. The barren, and value-carrying ores appear to be interstratified, and form a deposit, with its dip towards the south-east, and on only a very slight incline.

The work has been insufficient to base any estimates as to value of the prospect, but the indications point to there being a large deposit. I base this opinion on the showing in a number of shallow prospect holes sunk along the line of strike and from the outcroppings, which prospect some colors.

Crown Point, Sec. 19, T. 17, R. 11.—To the north-east of the Miller property about 2 miles distant, considerable work has been done, and a five stamp mill erected on the Crown Point mine. No systematic mining has been done here, although a small quantity of ore was run

through the mill in 1893. But the value saved was insufficient with such limited crushing capacity to produce profitable results. Consequently work was abandoned, before the value of the prospect, or extent of the ore body was determined.

A sample assayed by Dr. Pratt showed $3.23 in gold a ton. From this property the leads of gold bearing ore apparently follow the flanks of the mountain, one on the south-eastern and another on the north-western. Along the southern flank but little prospecting has been done, and such failed to expose any promising prospects. The work though was quite limited in extent, and if pursued systematically may yet result in the discovery of gold bearing ore bodies.

Moss-back, Sec. 35, T. 17, R. 11 E.—This was one of the early gold discoveries, made during the copper excitement early in the "seventies." The outcrop and ore near the surface yielded very fair results, as I am informed on reliable authority; but deeper mining operations appear to have resulted disastrously, jndging from the fact that both mine and mill have been deserted for years.

Two incline shafts were sunk on the lead of ore, one exposes an ore body 8 feet thick bedded between walls of a talcoid graphitic schist, or decomposed slate, resembling schist in appearance; the other an ore body 18 inches thick, bedded in the same country rock.

The last mentioned, was known as the "Houston" shaft, and I am informed the ore taken from it yielded by mill runs from $4.00 to $4.50 a ton in free gold. The first mentioned, was known as the "Company Shaft." This was considerably deeper than the "Houston," being some 30 feet. The ore taken from it was of lower grade than from the other, but the cost of mining the thick ore

body was of course less than the thin; which ought to have offset the difference in value.

A vertical shaft was sunk, with a view to cross cut the ore body exposed in the "Company" shaft at greater depth. While the work was progressing, I am informed, that the superintendent reported that the gold bearing ore had given place to copper bearing ore. He shut down the mill, and abandoned mining operations at once, and the same condition of idleness exists to-day. I was unable to explore the workings because of water, so can not verify my information by a personal examination.

A good ten stamp mill was erected on this property in 1890, and for several months quite extensive mining and milling operations were conducted.

Pritchard, Sec. 36, T. 17, R. 11 E.—Here an incline shaft some 15 feet deep, has been sunk for prospecting purposes, and about 7 feet of strata of auriferous sandstone, or quartzite has been exposed. This is bedded between talcoid graphitic decomposed slate or schist walls, with a slightly inclined dip towards the south-east, and its line of strike nearly north-east. By panning an average sample from the entire thickness this proved of low grade, about $3.00 a ton; but by selecting samples some very rich results were obtained.

Lucky Joe, Sec. 25, T. 17, R. 11 E.—This property is located to the north-east of the Moss-back and nearly north of the Pritchard, distant about three-quarters of a mile from either. Although, at the point that active mining operations were carried on in 1893, the formation on this property is contorted from the normal line of strike North-east to an abnormal line nearly due north yet I am inclined to class the Moss-back and Luckey Joe as belonging to the same lead of quartzite. Although I have never actually followed the outcrop of the formation, from location to location, yet the evidence of folding by lateral pressure is so well defined, by the crooked lines of the strike of the slates

on the Luckey Joe property, and the resemblance in the ore so marked, together with that of the country rock, that I feel convinced development will prove the correctness of my theory. But I doubt very much if the lead, should its continuity so far as formation is concerned be proven, will maintain any continuity so far as being gold bearing, is concerned.

Development in the Lucky Joe has already demonstrated that the pay ore is found in chimneys or shoots in the ore body. The property was first opened in 1893 to a notable extent, and a ten stamp Fraser and Chalmer's mill erected thereon, with all the latest improvements. But as it proved later, the management had committed the fatal mistake of erecting this plant before the property was sufficiently prospected to prove that a mine actually existed. Consequently the first clean up was not satisfactory, and all work was abandoned for several weeks. Later, after more extensive prospecting, other mill runs were made, which preved more encouraging; having demonstrated that $2.27 a ton could be saved in gold, by amalgamation. The cost of mining and milling, I was informed by the Superintendent (an experienced miner from Colorado) was $1.35 to $1.45 a ton. The capacity of the mill using 30 mesh screens, being 30 tons a day, together with the other facts I have mentioned, insured profitable results from mining and milling, provided that sufficient quantity of ore of that grade could be mined.

During the summer of 1894 I made a thorough examination of this property, because the success or failure were matters of vital importance to the gold mining industry of the state; and I wanted to determine, if possible, whether, in spite of partial failure due to the mistake made at the commencement, the condition of the property was such as to indicate future successful results.

I found, as I have already stated, that the pay ore lay in chimneys or shoots, which occurred through the so-called

ore body, of varying width and thickness. Therefore, while the vein matter is apparently quite extensive, yet only a limited portion carries values; consequently, during the first milling operations a large number of tons of barren material, having the appearance of pay ore, were milled. This, of course, reduced the yield of the ore itself to an insignificant figure.

The vein matter is a garnetiferous quartzite interstratified with a decomposed talcoid slate or schist, and by panning I ascertained that sometimes the value is in the quartzite, but more often the decomposed material pans the richest. The workings consisting of 300 feet of drifting and cross cutting show that the chimneys of pay ore are about four feet wide and three to four feet thick, dipping towards the east on about a 30 degree angle, with their line of strike a few degrees west of north These ore shoots lie almost parallel to each other, and up to the time of my visit three of them had been exposed. The centre one of these is wider than the others, and apparently the main channel, towards which the narrower shoots appear to be trending. The work being done at the time of my visit was to determine whether these shoots did actually concentrate to one main body of pay ore. A winze was being sunk from the 50 foot level, on which all the prospecting has heretofore been done, to determine the extent and permanency of the widest shoot at a greater depth.*

Smith and Wood's Old Copper Mines.—Paralleling the Pritchard ore body on its western side occur the old copper mines, worked in the early "seventies" I can only refer to these from information I could gain in the neighborhood, because all work has been abandoned for several years past, and the openings made at that time are all full of water to-day.

It is a matter of history that both these properties produced considerable copper 20 years ago. The ore was smelted in soapstone furnaces, the ruins of which still remain as land marks. This soapstone was quarried near by, from a ledge which occurs in the neighboring crystalline formation.

* A few weeks after my visit work was suspended again, and has not been resumed since to date, April, 1896.—W. M. B.

From the appearance of the water flowing from the old workings, the mines were evidently not entirely worked out, because scrap iron will precipitate copper in short time, and in considerable quantities. Some of the ore must evidently be fairly rich. From the most reliable information I can gather, the work was abandoned because of the average low percentage of copper, and excess of iron pyrites. The ruins of the plants, old dumps and general appearance of the surroundings indicate that quite extensive operations were carried on during the days of copper excitement. Between this group of mines and the state line to the north-east no occurrences of gold-bearing ore have been discovered.

Leaving the neighborhood of this group of mines, and traveling towards the north-west across the thick edge of this semi-crystalline belt, we cross the eastern flank of Turkey Heaven Mountain. No discoveries of any importance of gold-bearing ore have ever been made, until Section 2, T. 17, R. 11 E. is reached. We pass the

Head Mine, Sec. 13, T. 17, R. 11 E., on which considerable work was done a few years since, without resulting in any discoveries worthy of note, and I only mention it in this report to show that in my examination I have not neglected to notice any properties on which discoveries are claimed, or prospect work of any extent performed.

Hall, Sec. 10, T. 17, R. 11 E.—Some shallow prospect work has been done on this location, but such was not attended with any promising prospects being discovered, and is mentioned for the same reason.

**Hicks-Wise, Sec. 2, T. 17, R. 11 E.*—A greater vertical depth has been reached in the workings in this mine, and a more extensive ore body disclosed than at any in Alabama at the present period. A shaft, almost vertical, has been sunk 110 feet, or 27 feet below water level. About 3,000

* The present period referred to is the summer of 1893.—W. M. B.

tons of ore have been mined and milled from levels run from this shaft, at 20 feet, 40 feet and 85 feet from the surface. It is claimed that this ore yielded $2.00 a ton by amalgamation. It can hardly be classed as free milling ore, although no other treatment has been attempted. Because of the percentage of graphite it carries from the surface down, and the sulphurets below water level, amalgamation will never save full values.

The line of strike is Northeast with an almost vertical dip towards the S. E. The structure of the ore body can hardly be considered as determined. In the soft decomposed slates from the surface to water level, it has all the appearance of a mass of ferruginous sandstone, quartz and decomposed slate with the appearance of a stratified deposit of unknown depth, and width. At the 85 foot level (the deepest work I could examine, because of water and no pumping facilities), this ore body has been drifted on a distance of about 200 feet, and maintains its continuity; but at no point has it been cross cut to determine its extreme thickness. Both headings of the drift are in ore. A cave which occurred near the surface, shows a thickness of ore 25 feet, but whether that is the maximum can not be determined.

Assays on the Hicks-Wise I am informed by Mr. Julius Houston of Arbacoochee, show its value to increase from $2.00 a ton at the surface to $14.00 at 110 feet, at which point the sulphurets ran as high as $39.00 a ton. These assays I was informed were made by W. M. Courtis a mining engineer and chemist of Detroit, Mich., who made an expert examination of the property in 1893. Other assays are given below.

Lee Mine, Sec. 2, T. 17, R. 10 E.—This property was purchased in the spring of 1894, by a syndicate of capitalists from Cincinnati, and extensive prospecting work commenced.

The line of strike of the formation and ore body is Northwest with the dip slightly W. of S. at an angle of 45 deg. It has all the characteristics of a bedded vein be-

tween slate walls, which are well defined, better in fact than at almost any location I have examined in the State. The varying thickness of ore in a drift at 40 feet from the outcrop, on an incline conformable with the dip, is between 4 and 5 feet. An incline shaft has been sunk about 40 feet, from the surface down with the dip, where a cross cut tunnel from the south side of the ridge in which the ore body is located, intersects the bottom of this shaft. A drift 121 feet in length has been run on this level, in ore the entire distance, with ore in both headings, and nearly 80 feet of the drift showing the ore body to maintain its continuity at its maximum thickness. From the level of this drift an incline has been sunk 20 feet, showing the ore body to be 5 feet 6 inches thick at the bottom.

The plant at present in operation for treating this ore comprises three arastras, and a Blake crusher. The superintendent, Mr. S. Fehr of Cincinnati, informs me that by this treatment, he has demonstrated that the ore will mill $5.00 a ton in gold.

A fair average sample I took myself from the entire thickness of the vein as exposed at 15 feet deep assayed by Dr. Pratt of Birmingham, yielded $12.61 a ton in gold. The thickness of the vein at the point from which I took my sample was 2 feet 6 inches.

Crumpton, Sec. 7, T. 17, R. 12 E.—The occurrence of gold bearing ore discovered on this property, has not been prospected sufficiently to determine whether any ore body beyond the mass of outcrop, and irregular "blow out," as it may be termed, really exists. The ore is the same ferruginous quartzite, in the "Talladega" semi-crystalline formation, as that occurring in the Lucky Joe and Mossback; but the country rock shows less of the graphitic variety of slate than that in which those mines occur. However, as the line of strike on the Crumpton has its normal trend Northwest and the property is located on a

direct line geographically, with those mines I have mentioned, I believe I am correct in classing it as a possible extension, subject of course to determination by actual prospecting. Some of this ore pans very richly, especially that from some strata which are less ferruginous than the bulk of the ore.

Middlebrook, Sec. 3, T. 17, R. 12 E.—This property is located in the north-east corner of the north-west quarter of the section. The ore body is interstratified with the formation, having its strike North.east and dip South-east conformable with the country rock, the same "Talladega" semi-crystalline as is typical of this section of the gold fields. The ore is a ferruginous quartzite, and the body is capped with limonite. An incline shaft has been sunk about 20 feet deep showing a thickness of pay ore nearly 5 feet; from which I obtained not less than $5.00 a ton in gold, by panning an average sample taken from the entire thickness.

Ballinger, Sec. 2, T. 17, R. 12 E.—An occurrence of gold bearing ore, similar in character and at the outcrop of about the same relative value from pan tests as the ore found on Crumpton property, about 3 miles S. W., was discovered on this property several months since, but no attempt to develop or even prospect the outcrop has been made.

Sutherland, Sec. 34, T. 16, R. 12 E.—Here a body of gold bearing quartzite has been quite extensively prospected. This ore body, while bearing in some particulars, as to the stratified structure, a close relationship to the Middlebrook, yet may prove by development to be confined between well defined walls. Certainly it has a well defined slate hanging wall, but no solid foot wall has been yet exposed, unless a stratum of decomposed slate, should prove such. The slate hanging wall has faulted at the depth of about 30 feet below the surface, and threatens to cut off the ore body entirely, in one incline shaft sunk on an incline of about 45 deg. to a depth of 30 feet. At this point the fault in the slate was encountered and work suspended. The ore body had main-

tained a thickness of nearly 4 feet above this, and prospected very satisfactorily.

There are two other incline shafts, one 25 feet in depth, the other 15 feet.

The deepest of these two exposes nearly the same thickness and grade of ore, as in the first shaft mentioned. But in the more shallow pit, two bodies of ore which at the outcrop, near the pit, appear divided or separated by strata of decomposed slate have united, and the body of quartzite has an aggregate thickness of nearly 12 feet. But what proportion of this yields values I am not prepared to state.

Ore from this property has been milled in a temporary stamp mill constructed of wood throughout; except clumsily made iron shoes. The stamp stems are made of 4 in. x 4 in. scantling. The cam shaft, a log squared, about 12 inches through. The cams are cut, with great ingenuity and fastened into this log. The tappets were wooden pegs set in augur holes bored through the stems.

The results from milling in such a primitive manner, would hardly prove a fair test of the ore; even if such could have been obtained, which I found impossible.

Bennifield, Sec. 27, T. 16, R. 12 E.—This property has been prospected by several shallow open cuts, exposing the occurrence of gold bearing quartzite. This has every indication of being a stratified deposit, covering considerable area of undetermined thickness. The ore would be classed as low grade, so far as my tests by panning, without taking a sample in a thoroughly systematic manner, could be relied on. Some other shallow prospecting has been done in the neighborhood, but not sufficient to base any estimate on as to extent, value or permanency. More extensive work should be done, before any determination as to the value of any of this district can be arrived at. In fact the same proposition applies to the entire State so far as gold mines are concerned.

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Marion White, Sec. 6, T. 16, R. 12 E.—In this same "Talladega" slate formation, and to the north-west of the quartzite bodies just referred to, and within a short distance of the Georgia Pacific Railroad in Cleburne county, occur a few prospects, which are promising enough to warrant the performance of more work than has already been done. The most important of these discoveries is on the Marion White property, over which in 1893, there was considerable excitement because of some quite rich quartz specimens being found in which the free gold was visible to the naked eye. These were found as float. Prospecting exposed a thin vein of quartz with lenticular structure bedded in the slates, which also panned fairly well. But a sample which was assayed by Dr. Pratt only yielded $2.27 a ton in gold. The work was not of sufficient extent in the neighborhood. to warrant the expression of an opinion.

James Moore, Sec. 12 and 13, T. 16, R. 10 E.—This property is some 6 miles south-west of the White prospect. Placer mining of considerable extent was carried on in this neighborhood as well as on this particular property some years since. Sluicing in a ditch recently yielded some fairly coarse particles of gold quite rough, and ragged on the edges, denoting it had not been washed far. But for placer diggings the ground would not pay, and some little surface prospecting failed to expose any quartz body or vein bearing gold. Indeed, although the surface of the ground, through several properties in this settlement, is plentifully covered with float quartz, decomposed and porous to some extent, and plentifully stained with iron oxide, yet no ore body, or outcrop or even float carrying gold could be discovered.

Resume on the North-western Semi-Crystalline Belt.

I. The extent of this belt so far as the formation is concerned, and not including the Terrapin and Talladega Mountains, which, while the formation is the same, I shall treat separately, because the ore bodies in these mountains occur

on the north-west slope, and consequently really belong to a separate and distinct belt, is about 18 miles long with the line of strike, and 24 miles wide across the formation at its widest part, and contains about 300 square miles.

II. The ore through the entire belt is a sandstone, or ferruginous quartzite, which were it not for the presence of graphite, and sulphurets below water level, might be classed as free milling of low grade.

III. A few of the prospects such as Hicks-Wise's Crumpton's, and Middlebrook's may prove to be comparatively free milling; and permanent development work may result in profitable operations.

IV. Deeper work is warranted on most of these prospects examined, because of the rich results obtained from many, from the outcroppings, and the fact that so far as work has progressed the ore has maintained its continuity in value.

V. The permanency, and extent of these ore bodies, can only be proven by deeper and more systematic prospecting; while the values can only be determined by thorough test and sampling, by the various treatments known to science.

Results of Assays by Dr. J. H. Pratt, of Birmingham.

2058 Lee Mine, Sec. 2, T. 17, R. 11 E. $12.61 gold per ton, no silver.
2068 Gold Ridge, Sec. 34, T. 17, R. 12 E. $4.82 gold per ton, no silver.
1966 Hicks-Wise, Sec. 2, T. 17, R. 10 E. $3.14 gold per ton, no silver.
1967 Hicks-Wise, Sec. 2, T. 17, R. 10 E. $4.30 gold per ton, no silver.

HILLABEE (IWANA) GREEN SCHIST BELT.

A belt of light green colored, highly pyritiferous, altered eruptive rock occurs paralleling the "Talladega" slate proper of the Talladega Mountains, on the south-eastern edge; and apparently maintaining its continuity along the line of strike, from the Coosa River, near the mouth of Weogufka Creek, towards the north-east into Cleburne county.

This rock is distinguishable from the "Talladega" slates by the large percentage of unaltered pyrites it carries, as well as by its massive structure, hardness and toughness. These last characteristics cause it to be very difficult to drill and blast; while the quantity of crystals of pyrites imbedded in it has proved in the past very attractive to prospectors for copper ore. At the present day it is receiving attention from the prospectors for iron pyrites for treatment in the acid plants, in converting such into sulphuric acid.

With what degree of success this class of mining will be attended in Alabama, is impossible to determine at this early date; because the industry has not passed beyond the age of infancy.

The Chulafinnee and Arbacoochee Mining Districts

in Cleburne county are located on the south-eastern border of this formation. As early as 1842 placer mining was carried on in these districts very extensively. Especially was this the case with regard to Arbacoochee, when the town bearing that name was a typical placer mining camp, in all that the name implies. The stories of big nuggets, and rich pockets or beds of gravel, are

to a certain extent facts, proven by the returns from the Mints, in which Alabama is credited with producing $365,300.00 in gold between the years 1799 and 1879, the bulk of which came from this district. I group these districts under one head because they are in the same geological formation, the continuity of which is maintained throughout. While Chulafinnee is located about 10 miles to the south-west of Arbacoochee, and across the Tallapoosa River, yet from a miner's standpoint the relationship between the two localities is so close that I am justified in classing them under one head; although I shall consider the occurrences of gold-bearing ore and gravel in each separately.

The Chulafinnee Mines are located, so far as at present discovered, in Secs. 14, 15, 16, 23, 24, 25, T. 17, R. 9. E. The most extensive placer mining in the past was done on these tracts, through which the waters of Chulafinnee and Carr Creeks flow.

Judging from the extent of the tailing dumps and workings, the gravel beds must have been quite extensive. But these have been worked out where profitable, and to-day some five or six feet of surface soil have to be removed to reach gold-bearing gravel, which will pay an average of 75 cents a day to the man by sluicing. Consequently these cannot any longer be considered as paying placer mines, though the formation would warrant investigation with the view of adopting hydraulic mining, and such might prove profitable because the gravel beds exposed under the soil are apparently of considerable extent.

So far as quartz mining is concerned, but little work has been performed, except at the

King Mine, Sec. 16, T. 17, R. 9 E.—Here a stamp mill was in operation in the "seventies;" but work was abandoned, it is claimed, because of litigation. The old

openings show that mining was carried on quite extensively; but it is impossible to form any estimate of the extent of the ore body, because the deeper shafts are filled with water, while the shallow openings have been abandoned so long they are filled with debris. In one pit, near the surface, I was enabled to expose a seam of hard white quartzite about six inches thick, having a N. and S. strike, and dipping nearly vertically towards the E., bedded in strata of decomposed schist. This, however, could hardly have been what the owners were working, because it only assayed $1.03 a ton in gold.

From the extent of this pit, the mouth of which covers an area of some 2,500 square feet, it would appear as though the country rock had been milled, as well as the thin strata of quartzite.

Striplin, Sec. 22, T. 17, R. 9 E.—Here sufficient prospecting has been done to show the occurrence of a body of gold-bearing quartz of irregular structure, characteristic of such outcrops as miners designate as "blow-outs or burst-ups."

The shallow openings were made on the summit of a ridge, extending N. E. and S. W. between the head waters of Carr Creek. The gravel in both of these branches is gold-bearing, and the old dumps and pits show that placer mining of extent was done in the past. Sufficient depth was not reached in this prospect work to determine any facts relative to extent, value or permanency.

On the south-east slope of this ridge another pit some eight or ten feet deep exposes some narrow stringers of a white sugary quartzite, with a north and south strike and almost vertical dip towards the east, bedded in strata of decomposed schist, apparently the same as occurs in the Arbacoochee mines. This prospected fairly well by panning without crushing, thus showing that the gold from the quartz had been disseminated through the

decomposed schist, to some extent.

The quartz in this prospect I preserved after panning, and by assay it yielded $3.31 in gold a ton.

Samples I took from several outcrops assayed between sixty and seventy cents a ton in gold.

A discovery has been recently reported (Sept., 1894) as having been made on the

Higginbottom Property, adjoining the Striplin on the north-east. The ore body resembles the thin strata of quartz and decomposed schist described as occurring on the Striplin land. It pans very richly at the surface, and is sufficiently promising as a prospect to warrant the performance of work, to prove its extent and value at depth.

Between the Chulafinnee mines and Arbacoochee mines no discoveries of gold have been made. In fact, I can learn of no prospecting work of recent date that has been done; although the formation maintains its continuity and gold can be panned out of the gravel in nearly any of the creek beds or gullies, in small quantities.

Arbacoochee Mines, Sections 5, 6 and 7, T. 17, R. 11 E. These sections, I learn from information, as well as observation, judging from the old dumps and workings, furnished all the gold credited to Arbacoochee in the old days of placer mining.

To-day there are spots on either of these sections which yield profitable results from sluicing, and a large area would pay for hydraulic mining, provided water could be obtained in sufficient quantity, and pressure by gravitation.

On section 5 hydraulic mining has been carried on at irregular intervals for several years past. But as no record of the yield has been kept, it is impossible to make any reliable estimate of the amount of gold cleaned

up. Traditions are related which, however, cannot be sufficiently reliable to base any statistics upon. Many of these place fabulous values on some pockets and beds of gravel washed out in the past. Nuggets ranging in value from $1.00 to $1,300.00 are claimed to have been found by different miners at various spots throughout the entire district.

There is one feature which deserves attention, and it is the fact that at no point has solid formation been reached in the old workings. The bed rock has been considered to be a red clay* which underlies the gravel beds. These gravel beds occur in pockets about three feet in thickness, and very close to the surface, on a ridge, which apparently was the bed of the creek, which has since cut its channel to a considerable depth below the summit of this ridge.

To determine the present value of these hill "diggings," as they may be termed, would require a vast amount of time and actual work, which the survey is not prepared to devote to it.

In 1893 an expert examination was made by W. M. Courtis, of Detroit, Mich., of a portion of *Sec. 6, known as the "Denson" property*. This expert informed me at that time that the value of the placer ground on a portion of the section was 20c. a yard. However, he gave me no figures as to extent, which, of course, would be most important. But as to water facilities, he informed me it would be necessary to bring the supply from the Tallapoosa River, the nearest point being about two and a half miles.

Considerable prospecting for quartz veins has been done in this district with varying results. But no plant has ever been erected to treat any of the gold-bearing

*This "red clay" is in many places seen to be merely the thoroughly decomposed rock, the "saprolite" of Prof. Becker. See also Report of Alabama Geological Survey for 1874, p. 44. E. A. S.

quartz, although several veins (usually thin) have been exposed in the prospect pits, which yield good results. Some very fine free gold specimens, the quartz carrying the gold being of a whitish sugary nature, have been found both as float and in some of the vein stone.

The maximum extent in width of the Arbacoochee gold-bearing gravel belt is attained on sections 5 and 6, where it is fully one mile across from the northwestern to the southeastern boundaries. One very noticeable difference occurs in the country rock on the north-western side of this belt and that on the south-eastern, or rather in the formation which parallels this "Iwana" rock formation on the north-west, and that which parallels the placer district on the south-east. The "Talladega" slate beyond the north-western boundary is less crystalline, and carries no "iron garnets" (i. e., altered pyrites) ; but apparently the same type of slate beyond the south-eastern body is very highly garnetiferous, and almost fully crystalline, graduating into hydro-mica and mica schists further to south-east. Another appreciable difference is that the formation to the north-west for a distance of at least five miles is, so far as at present known, entirely non-mineral bearing ; while on the south-east it is gold bearing.

In following the Arbacoochee belt towards the north-east and along the Trickem Valley, I found that less regularity existed in the maintenance of its width than is the case to the south-west. Although towards the south-west the pay diggings are found to occur only in spots, yet the formation maintains its continuity and average width yielding colors generally where any gravel is washed, beyond the recognised limits of the placer diggings ; but not sufficient to warrant its classification as pay dirt.

Hence, while the formation is continuous from Chulafinnee to Arbacoochee, it is only on the tracts I have par-

ticularly referred to that pay diggings really occurred.

Near and below water level quicksand occurs in this formation through the northerly portion of the district, but in the southerly hard bed rock is reached at shallow depth.

In a north-easterly direction from Sec. 5 the placer belt diminishes in width very rapidly, and near the north-west corner of Sec. 2, T. 17, R. 11 E., it is entirely lost, so far as the State of Alabama is concerned; at least, so far as is at present known from the prospecting that has been done.

During the summer of 1895, the Hilton Brothers and R. E. Merrill obtained an option on 200 acres of section 7, and the first named a lease on 20 acres of the Denson property on the west half of section 6, and immediately adjoining section 7 on the north side. This action was based on a tradition of a very rich find made by a man named Marable in the "forties," in the placer ground drained by Clear Creek. The father of the Hiltons had marked the location of this find, and bequeathed the knowledge to his family before his death. The understanding was, that at any time the brothers could obtain an option or lease on the property he designated, that they should work it for the benefit of the family. Tradition said that Marable had taken 11¾ lbs. of gold from this pit in a half day, celebrated his discovery by a carousal, during which he died. The pit in the meantime had filled with water, and had not been disturbed since that day in the "forties," until the summer of 1895.

After prospecting for some weeks the ore was encountered, together with a large quantity of gold dust and nuggets. The most important feature of this discovery was the auriferous quartz in place. A dispute arose between the owners of the properties relative to the land line as soon as the discovery was made, which caused

the suspension of operations at that particular point. When work was stopped, a fresh fracture in the quartz in place showed native gold imbedded in it, in sufficiently large particles to be visible to the naked eye 20 feet distant.

The country rock proved to be a gneiss,* in which the auriferous quartz was bedded, the strike and dip conforming, so far as seen, with the structure of the country rock. Sufficient work had not been done to determine the structure of this ore body, or its permanency. In thickness it was about six inches.

The result of this discovery was the performance of a large amount of prospecting work by a Chattanooga syndicate to which the Hiltons had sold their option. This was done at several points on section 7, and is being carried on at the time of making this report.

Other adjoining properties shared in the activity and the entire district changed its aspect from one of abandonment to one of life.

T. H. Aldrich of Birmingham optioned the east half of section 6, or the Creamer property, as it is locally called. He commenced a systematic method of prospecting to endeavor to discover the rich ore body to the north-east along its line of strike. Several cross cut trenches were dug, and at two points the ore body, or what was apparently the same, was cross cut. These were located about 1,000 and 1,700 feet, respectively, from the Marable. If these belong to the body discovered by the Hiltons, then there is every reason to believe that a series of faults occur in the formation which have thrust the body from its normal line of strike, because where discovered by Mr Aldrich, the auriferous quartz is 600 or 700 feet north of the normal line of strike. This theory is tenable from the fact that in a shaft sunk 30 feet south, of the Marable pit, a well defined fault is seen, and in a pit sunk a few degrees west of south of the Marable

*See Mr. Brooks' notes, Part II of this report. E. A. S.

pit, a few feet distant, and on the line of strike of the ore body, such was not exposed. If the ore body was continuous, it must have been exposed in this pit.

The same country rock as is encountered in the Hiltons' workings is found to extend through the east half of section 6 to the north-east, as well as through section 7 to the south-west, and is apparently about 800 feet wide. This is a gneiss, and further examination proves that the same character of country rock is continuous through this as well as the Chulafinnee mining district on the opposite side of the Big Tallapoosa river, crossing that river in the vicinity of Denman's bridge. Several bodies of auriferous quartz, of low grade, at the outcrop, cross the east half of section 6, but have not been prospected beyond its lines.

The Anna Howe, Anna Howe Extension and Crutchfield ore bodies form the north-western boundary of the placer diggings, and undoubtedly have furnished a great deal of the gold found in those diggings.

Although the outcrops of neither the Anna Howe nor the Crutchfield can be traced above the surface to the south-west beyond the west line of section 5, with sufficient clearness to establish continuity along the line of strike, with any of the quartz bodies in the Chulafinnee district, yet from the similarity in the relations of the two, I am of opinion that the ore body at the King Mine in Sec. 16, T. 17, R. 9 E. is really an extension of the Anna Howe.

In Coosa county some 60 miles or further to the south-west, in the same formation, (Talladega slate, close to the Iwana or Hillabee schists) we find the old *Parson's Mine, Sec. 4, T. 23, R. 17 E.*, which was worked quite extensively 4 or 5 years since. Here we have a narrow quartz vein with lenticular structure bedded in the slate, having its strike N. E. and dip towards the S. E. at 45 deg. When I visited this mine, in company with Dr. Eugene A. Smith, during the summer of 1894, we found it impossible to determine any facts with regard to permanency, extent or value

of the ore body. The old pits and dumps, open cuts, and deep shafts denoted that the mining operations had been on quite an extensive scale; but not performed systematically, or apparently with any view to development for future mining. The idea being, as it seemed to me, to obtain what ore could be got as cheaply as possible, and let the workings fill up with water or cave in.

But to return to the *Anna Howe Extension, Sec. 34, T. 16, R. 11 E.* and *Crutchfield on the same section,* in fact a portion of the same property.

The ore of the last named has been discovered at no other points except on this property, and on Sec. 3, T. 17, R. 11 E.

The abandoned pits along tbe line of strike of this ore body on Sec. 34, are evidence of the work done in the past, when as I am informed some $2,500.00 was taken out of the vein, which varied from 4 in. to a foot thick, from shallow pits. These were sunk 10 or 15 feet on the dip of the ore body, which lies almost flat, dipping towards the south-east. All the ore that could be worked out, without timbering or danger from caving, was mined. That pit was then abandoned for another, to be in its turn worked out and abandoned, until the line of pits reaches for nearly half a mile in a course slightly north of east.

On Sec. 3, T. 17, R. 11 E. known as the Valdor property, a shaft about 10 feet deep has been sunk on an ore body, apparently an extension of the Crutchfield. An ore body or bedded vein, having lenticular structure, and varying in width from 4 inches to a foot has been exposed. This dips to the south, lying almost flat, and has its line of strike N. W. at this particular spot. But on Sec. 34, the vein has the normal line of strike general in the Alabama gold fields N. E. Except that the ore has the same appearance, and in general characteristics, except strike and direction of dip; these ore bodies bear strong resemblance, bnt I can not determine positively that the Valdor is

an extension. The fact that the line of strike of the slates changes on the *Anna Howe, Sec. 33, T. 16, R. 11 E.* makes a strong presumption for the theory in favor of the extension.

The Anna Howe itself was one of the first gold bearing quartz discoveries in the Arbacoochee district. It is a segregated or bedded vein of highly sulphuretted white quartz, plentifully stained with iron, and partially porous and decomposed. From the surface down, a distance of about 100 feet, on an incline with the dip of the vein, the country rock enclosing this ore body, had much the same appearance of decomposed schist and quicksand as is found in the placer diggings. But at that depth this gave place to the solid "*Iwana*" or *Hillabee* schist walls, highly pyritiferous, carrying crystals of unaltered pyrites, in quite large cubes, as well as forming a large per centage of the entire mass of slate. When this solid formation was reached, I am informed, that the vein pinched out entirely, and further work was abandoned.

That portion known as the Anna Howe was sold to a syndicate composed chiefly of New Orleans capitalists, who organized as the Anna Howe Gold Mining Company. A Huntington Mill complete, with Frue Vanner concentrating table attached, was erected, and treatment of the ore commenced and continued until, as I have already stated, work was abandoned when the ore pinched out. Since that time the mine has remained idle, and the workings and incline shaft are full of water. The prospectus of this company signed by George D. Stonestreet, Mining Engineer, and Member Am. Institute Mining Engineers, is certainly a work of art, so far as estimates with regard to extent and permanency of the ore body is concerned. He figuring on 190,728 tons of ore in veins, and 297,000 tons of placer gravel in sight approximately, as well as figuring on the yield of a profit of $6,646,857.00, or 40¾ per cent. per annum. As an actual matter of fact, it is absolutely impossible to

figure on any ore in sight, even under the most favorable circumstances. Because, as I am reliably informed and as the extension shows, the ore body has that irregular lenticular structure, on which it is very unsafe to form any estimates regarding the quantity of ore in sight, even when the mining is of such a character as will enable any estimates to be made. Besides this, the ore body at its thickest was only a narrow seam, as is shown on the extension. I call attention to these facts not to condemn any particular man or property; but because I consider it against the best interests of the state for such perverted and exagerated statements regarding the facts to be published and circulated.

About the same time that the Anna Howe was sold, and the company organized, a syndicate of Birmingham and New Orleans capitalists purchased the *Extension on Sec. 34, T. 16, R. 11 E.*, and organized another company. Active mining operations were carried on for a while, which were chiefly confined to the Crutchfield vein which I have described earlier in these pages. No plant was erected by this company and work was abandoned when the same course was pursued at the Anna Howe mine proper.

Recently work has been resumed on the extension, by a lessee; who pumped out an old shaft sunk in 1877 and continued sinking in order to cross cut the ore body at depth in the solid formation and prove the conditions there existing. After sinking for several feet, and attaining a depth of some 60 feet from the surface, the water became of greater volume than the capacity of the pump, and work on this was suspended. The only results demonstrated were the extreme hardness of the "Iwana" and rock, that the percentage of pyrites carried by that rock, did not increase to any marked extent as the sinking progressed.

The lessee then re-opened an old tunnel and incline

which had been abandoned when mining was discontinued. From this opening he succeeded in taking out about ten tons of a highly sulphuretted quartz, somewhat decomposed and porous in spots, as well as being plentifully stained with iron oxides. This he attempted to mill and treat by amalgamation, saving the concentrates with blankets. He informed me that he succeeded in saving $175.00 from the ten tons; besides the concentrates, of the value of which he was unaware. From the appearance of the ore, and all the general characteristics of the formation, this is certainly an extension of the Anna Howe vein. The ore body is only a few inches in thickness, and has the lenticular structure, and almost flat dip, typical of this district in the quartz veins.

On Section 5, T. 17., R. 11 E., an ore body resembling the Anna Howe vein has been exposed in a shallow prospect hole, but sufficient work to determine its extent had not been performed at the time of my visit. Some of the ore near the surface, after being thoroughly roasted and treated by stiff amalgamation, yielded about $30.00 a ton in gold. This ore though is not adapted for any treatment other than barrel chlorination or smelting, or possibly the cyanide process.

The line of strike of the Anna Howe vein is irregular, and by actually following the formation I found it assumed a zigzag course. Consequently it is found, especially towards the north-east from Sec. 34, to change from North-east to North-west several times within a few miles. Near the north-west corner of Section 2, T. 17, R. 11 E., it assumes its normal line of strike; but near there it is apparently cut off by a fault, and together with the placer belt is lost to the north-east so far as Alabama is concerned. From the geological conditions surrounding the locality, there is foundation for the theory that the Camille Mine in Haralson county, Georgia, is the north-east extension of the Anna Howe ore body.

Assays.

Assays by Dr. J. H. Pratt, of Birmingham, Ala., on samples from the Chulafinnee and Arbacoochee Districts, resulted as follows:

2049 King Mine, Sec. 16, T. 17, R. 9 E., $1.03 in gold per ton.
2051 Valdor, Sec. 3, T. 17, R. 11 E., Crutchfield vein, $5·17 a ton in gold.
2054 Striplin, Sec. 22, T. 17, R. 9 E., $3.31 a ton in gold.
2057 Anna Howe, Sec. 33, T. 16, R. 11 E., $12.40 a ton in gold.
1976 Reeves' Shaft, Sec. 6, T. 17, R. 11 E., $2.40 a ton in gold.
1977 " " Sec. 6, T. 17, R. 11 E., $2.36 a ton in gold.

TALLADEGA AND TERRAPIN MOUNTAINS.

Riddle's Mill. On Sec. 16, T. 19, R. 6 E., in Talladega county, near Waldo P. O. or Riddle's Mill, there is an occurrence of gold-bearing quartz. This is on the northwestern flank of the Blue Ridge Range of Mountains, locally known as the Talladega.

The ore body is a white quartz, highly sulphuretted, and having its line of strike North-west, with its dip almost flat, and towards the S. E. The structure is that of a bedded vein, of lenses or kidneys of gold-bearing quartz; with its continuity maintained with depth, so far as mining has exposed to the depth reached, not to exceed 100 feet on an incline with the dip of the ore body. But in the connection found to exist between the lenses or kidneys, the thickness of the streak pinches to a mere trace; while these kidneys rarely exceed four inches at the thickest part. The value of this quartz varies from $20.00 a ton in gold to $150.00 by assay test. The country rock is the "Talladega" variety of semicrystalline slate.

Some fabulously rich pockets, I am informed, were discovered at and near the outcrop. At one time a syndicate from Birmingham, Ala., mined and milled the ore for about 6 months; but work was abandoned because of the inability to save values by amalgamation.

A system of concentration was also adopted but proved unsatisfactory. Since then several local miners have from time to time leased the property, and sometimes made good wages with a pan, pestle and mortar, by crushing the surface ore, and panning it. During the summer of 1894, Mr. Walter Riddle one of the owners, milled the ore mined by lessees, in a small mill with light stamps, with some degree of success.

The continuity of this vein is maintained along the line of strike with well defined regularity, for a distance of some two miles to the south-west from the north line of Sec. 16. Mining of considerable extent but in a primitive method has been done on the Riddle property, and the prospect pits extend for over half a mile.

On the Woodward tract in Sec. 16 and adjoining the Riddle the same ore body has been prospected to a limited extent.

In a south-westerly direction from this last mentioned prospecting, the vein crosses Talladega creek, and can be followed by the float and outcrop of the country rock to the old

Story Mine, Sec. 17, T. 19, R. 6 E. where quite extensive mining operations and some milling were carried on several years since. The ore was mined from the surface down, on an incline with the dip some 60 feet. At the heading, and where exposed along the sides of this incline, the ore body shows the same characteristics as on the Riddle, and Woodward properties.

Towards the north-east I can learn of no successful prospecting in this formation having been done.

Some 3 miles to the north-east of Ironaton, a Mr. Seay the original owner of the Clifton Iron Company's ore lands, has prospected for years for silver. His prospecting work is founded on the traditions from the Indians, in which he apparently has implicit confidence; because although his work has invariably resulted in failure yet he persists in continuing his search.

Further to the north-east in the Terrapin Mountains and in the same "Talladega" semi-crystalline slate formation, but on the extreme north-western edge are occurrences of quartz. These, or rather some of these, I find by prospecting carry a little gold at the outcrop, but not sufficient to warrant, in my opinion any investment of capital, to develop. But no work of any extent has ever been done. The quartz seams bear a strong resemblance to those around Waldo,

and are impregnated with crystals of iron pyrites, sometimes measuring nearly an inch across the faces.

Graphitic slate.—There are indications of a deposit of graphite on *Sec. 2, T. 13, R. 11, on the Treadway plantation.* A short tunnel run into a bed of graphitic slate, highly pyritous, several years since has exposed such a deposit. It is possible that further work might result in exposing a deposit of solid pyrite.

Assays.

Assays by Dr. J. H. Pratt show the following results:
1993 Riddle's near Waldo, $35.97 a ton gold; 83 cts. silver.
1994 Woodward's $145.83 a ton gold; $1.58 silver.

MICA AND KAOLIN DEPOSITS—UPPER BELT.

There are, as far as my observations have reached, associated with Alabama gold belts, four distinct belts of granite veins carrying mica, and feldspar. Their commercial value, and importance, are to-day almost entirely speculative, because of the limited extent of the mining operations, as well as crudeness of the actual work done in the past, and shallow depth attained in the workings.

The feldspar is found, so far as present development shows, usually in a state of decomposition, or as kaolin. This result of decomposition has been promoted by the action of the carbonic acid of rain and other waters, which removes the alkali; also by that of the organic acids which the decomposition of plants or animals contribute to such waters.

While apparently several quite extensive beds of this kaolin exist at some points along the mica belts, yet at present the extent is unknown, because no systematic work calculated to determine such has been performed.

On the Denman property, Sec, 21, T. 17, R. 10 E., the indications are that a bed exists capable of producing a sufficient quantity of high grade kaolin, to warrant the erection of a plant for the manufacture of fine porcelain, in the vicinity of Heflin in Cleburne county, on the line of the Georgia Pacific Railroad 8 miles distant from the mines.

Several tests have been made of this kaolin as to grade; and ware has been manufactured from it. This, I am reliably informed, was pronounced equal to any ware manufactured from the imported China clay.

The only vicinity where feldspar, in crystals, sufficiently hard and pure to possess a commercial value, has been discovered, up to the present time, is in the neighborhood of

Hissop P. O. in Coosa county.—There a fine body of

considerable extent has been mined and some sample shipments, made to the Standard Coal and Coke Company of Brookwood, Ala. Such has been successfully used in the coal washers for bedding by that company, and will probably lead to the establishment of a new industry in the State, *i.e.* prospecting and mining feldspar.

The mica bearing belts are apparently south-western extensions of those of North Carolina and Georgia. Although their continuity can not be traced from the north-east by the surface indications, yet we find from the geological formations, and geographical locations that this theory is tenable and warranted.

The most northerly location of any mica of commercial value occurs on

Sections 23 and 21, T. 17, R. 11 E.—While the surface indications are very encouraging on these properties, yet but little work has been done in developing the discoveries, and no estimate as to permanency or value can be made.

To the south-east from these sections, and near the northern boundary line of Randolph county, occurs what I consider the mother ledge, so far as Mica and Kaolin are concerned.

This belt attains its maximum width in *Randolph county, in the vicinity of Pinetucky Gold Mines.* In this vicinity the width is about five miles; but to the north-east and south-west, while the continuity of the granite veins is maintained an undetermined distance, the width of the belt, so far as at present known, is much less.

Surface indications of mica deposits, of commercial value, occur along the lines of strike of the Pinetucky granite veins both to the north-east and south-west, at several points. Especially so is this the case in Clay county. But in no other portion of the crystalline region of the state have I found deposits, where the prospects

for obtaining mica of a commercial value, cover such an extensive superficial area as do these.

The most extensive mining operations have been carried on at the properties of *Miller, Sec. 1; Phillips, Sec. 1; and Merrill, Sec. 12, T. 18, R. 10 E.*

From all of these properties mica has been mined and shipped for use in stoves and furnaces. Samples have also been sent to the leading electrical companies for test as to quality for their use. Such have been pronounced by experts as being thoroughly well adapted for use for electrical purposes.

Good surface indications and outcrop occur on the *Ayres and Linville properties in Sec. 19, T. 18, R. 11 E.; also on the Messer land, Sec. 18, T. 18, R. 11 E.; White's, Sec. 6, T. 18, R. 11 E.; Crews' Sec. 30, T. 18, R. 11 E.; Lander's Sec. 22, T. 18, R. 10 E.; and on several other tracts of land in this same neighborhood, owned by the Birmingham Banking and Trust Company of Birmingham, Ala.* These last mentioned tracts form a portion of some 30,000 acres purchased a few years since by Dr. Caldwell and associates, when it was expected that a railroad would be built through this portion of Randolph county.

Shallow prospecting pits have been sunk at several locations on all these tracts; but the only deposit which has been sunk on below water level is on the Merrill property, adjoining the *Pinetucky Gold Mining property.* There water came in and interfered with the sinking of a shaft at 55 feet below the surface. Below this point the size of the mica crystals, and grade of the sheets after the crystals were split, were superior in a marked degree to that taken from nearer the surface.

No mining calculated to show the extent or permanency of the veins in which the mica is found has been done at any of the prospects. The only object apparently in view when work was in progress, being to take out all the mica in sight without any regard to future devel-

opment of the properties. Consequently the result has been such as renders it absolutely impossible to estimate with any degree of reliability the extent, permanency or value from material in sight. There are in all probably 30 veins which carry mica in crystals of sufficient size to warrant being prospected, occurring on the strip of which I have given the width as five miles. Many have not been prospected at all, and all of which have been prospected only carry mica in paying quantities in spots. Actual shipments have only been made from a very few mines, and such only in limited quantities.

To the south-west and across the Tallapoosa River on this belt there has been very little work done prospecting for mica, feldspar or kaolin. The surface indications at some points near the village of Delta show that good mica may possibly be fouud if prospected for.

About five miles north-west of Lineville the outcroppings show good indications of the occurrence of mica, but samples I have seen from the vicinity show too much iron stain to render the mica adaptable for electrical uses, and the work is too shallow to assist in determining its quality at depth. Some little work has also been done on Lundy Mountain, near Chandler's Springs, and fairly good mica obtained.

The third belt occurs on the extreme south-eastern border of the Mica-schist gold belt. In and around *Rockdale, in Randolph county,* considerable prospecting work has been done, but the work has been abandoned some years since, and I can obtain very little information regarding the results. The properties on which this work was done form a portion of the land owned by the Birmingham Banking and Trust Company, to which I have before referred.

The fourth belt of mica deposits occurs paralleling the south-eastern edge of the Silver Hill Gold Belt, in Tallapoosa county. To this occurrence of mica I have already

referred in my report on the Silver Hill belt. It is impossible to obtain reliable statistics as to the quantity of mica which has been mined in Alabama up to the present time; but the extent of the work done at the mines is so limited that the output must necessarily be also limited.

There are many pre-historic pits of considerable depth and extent found in the vicinity of some of the mica deposits, where trees of large dimensions have grown on the old dumps, and in the bottoms of the pits. But when such work was done, or whether the incentive for the work was mining for mica or feldspar, cannot be ascertained to-day

PART II.

SUPPLEMENTARY NOTES ON THE MOST IMPORTANT VARIETIES OF THE

METAMORPHIC OR CRYSTALLINE ROCKS

OF ALABAMA;

THEIR COMPOSITION, DISTRIBUTION, STRUCTURE, AND MICROSCOPIC CHARACTERS.

A. A GENERAL ACCOUNT OF THE CHARACTER, DISTRIBUTION, AND STRUCTURE OF THE CRYSTALLINE ROCKS OF ALABAMA, AND OF THE MODE OF OCCURRENCE OF THE GOLD ORES.

BY

EUGENE A. SMITH.

The gold region of Alabama occupies a triangular area in the eastern part of the state, bounded by a line entering the state from Georgia five or six miles south of the parallel of 34 deg., running thence south-westward to Jemison, in Chilton county, and from that point through Wetumpka to Columbus, Ga. In this area are included parts or all of the following counties: Cleburne, Clay, Talladega, Coosa, Chilton, Elmore, Tallapoosa, Macon, Lee, Chambers and Randolph, aggregating about 4,425 square miles in area. It is the termination towards the southwest of what has been termed by Prof. G. F. Becker, of the U. S. Geological Survey,* the Georgia belt of the Southern Appalachian Gold Fields.

THE ROCKS.

These are practically all *metamorphic* rocks which, considered from the point of view of their origin, fall into two classes, viz., those derived from sedimentary or fragmental rocks, and those derived from igneous rocks. Until recently, all metamorphic rocks were considered as belonging to the first of these classes, the planes of schistosity passing for the bedding planes of the original

*Reconnoissance of the Gold Fields of the Southern Appallachians, in the 16th Annual Report of the Director of the U. S. G. Survey.

sediments, but modern petrographers have shown that through the agency of crust movements accompanying the upheaval of mountains, etc., the massive igneous rocks may be crushed and sheared in such a manner as to produce in them planes of easy cleavage or schistosity, in appearance similar to the bedding planes of the altered sedimentary rocks. By the same agency, planes of cleavage or schistosity may be developed in the sedimentary rocks also, and these secondary cleavage planes may or may not coincide with the original bedding planes. By the study of thin sections of rocks by means of the microscope, it is possible in many cases to determine whether or not a given specimen is made up of water-worn or rounded fragments, i. e., whether or not it is of sedimentary origin.

In other cases it may be impossible to determine even this much without closely examining a large number of hand specimens, or better still, extended observations in the field. It must be understood, therefore, that the assignment here given of our metamorphic rocks to one or the other of the classes named, is not by any means to be considered as final, since they have as yet been comparatively little investigated in the light of modern methods.

Similarly as regards the age of these crystalline rocks, they cannot be brought into a single class, for the Talladega slates, being sedimentary, must rest upon still older rocks, whose debris has furnished the material out of which they have been built up, and in the gneisses and some of the hornblendic schists we probably have the representatives of this older class. Again, the diorites, granites, and other intrusive rocks which fill the fissures in this older set, are of course more recent than the rocks which they traverse. The Talladega slates, in their turn, in places apparently enclose masses of intrusive granite, which by consequence would be

younger than they are. So, taking the great country-forming series, the gneisses and the Talladega slates, we have the representatives of at least two distinct eras, and in the intrusive rocks possibly a third, although part of these may be contemporaneous with the Talladega series.

In the present state of our knowledge, the older gneisses must be classed with the *Archæan*, while the Talladega slates will probably be assigned to what the Geologists of the U. S. Survey have named the *Algonkian*. One can, however, hardly avoid the suspicion that some of these semi-crystalline slates are no older than the Cambrian, although as yet the fossils have not been found to prove it.

The bulk of the eruptive rocks also will probably have to be assigned to the Algonkian.

1. ALTERED SEDIMENTARY ROCKS.

Ocoee, or Talladega Slates and Conglomerate.

Distribution.—As regards their surface distribution, the Ocoee or Talladega rocks are found in four or five roughly parallel belts, running with the general structure of the country, i. e., north-east and south-west. The main belt is that which lies furthest to the north-west, and borders the Cambrian and Silurian strata of the Coosa Valley. This belt has a width of five to ten miles according to locality, and it appears as a range of mountains with some of the highest elevations in the state. The names Blue Mountain, Talladega Mountain, Rebecca Mountain, etc., are applied to this range in different parts of its course, Talladega Mountain being the most generally applicable name. This range entends through Cleburne, Talladega, Clay and Coosa, into Chilton county where it passes gradually below the sands and clays of the Tuscaloosa formation of the Cretaceous.

The other areas of Talladega slates are found as narrow strips in the midst of the gneisses, much as though they had been accumulated in troughs of these rocks, yet other, and possibly more probable, explanations of their present attitude may be given. Two of these interior belts, as they may be termed, are wider and more persistent than the others, and of these, the one lying nearest to the main mountain belt, i. e., furthest northwest, is the more important. This belt extends through Coosa, Tallapoosa, Randolph and the lower part of Clay. It widens and ramifies towards the northeast in Randolph county, and it may be called the Goldville belt, since it includes Goldville, Hog Mountain and other localities formerly much worked for gold.

The next belt may be followed from near Eclectic, in Elmore county, north-eastward through Tallapoosa into Randolph, and through it to the Georgia line; but in the eastern part of Randolph its limits are not so clearly defined as they are in the rest of its course. In this belt occurs the Silver Hill gold mining region which was formerly much worked, and we name it accordingly.

There are in addition to these, two minor belts of altered sedimentary rocks, viz., one in Coosa county running north-eastward nearly through Rockford and merging into the main mountain belt beyond Goodwater; and one in Lee county, extending from Farrall's Mill by Wright's Mill to Chewacla and Springvilla lime works, beyond which it has not as yet been certainly identified. This will be mentioned again in connection with its most characteristic rocks, the crystalline dolomite.

Rocks of the Talladega Series.—The most abundant of the rocks of this series is a smooth, nacreous, *clay slate*, or *argillite*, of brownish gray, to greenish colors, feebly crystalline, and in places very closely resembling some of the variegated shales of the Montevallo series of the

Cambrian formation, and there are localities near the contact of the Cambrian with the Talladega, where the Cambrian shales, being slightly altered, are almost identical in appearance with some of the Talladega slates. Such partly altered shales of undoubted Cambrian age may be seen along the line of the L. & N. R. R. below South Calera, and in the vicinity of Clear Creek and Jemison; in the Kahatchee Hills in Talladega county; and further north-east in Calhoun county near Davisville; and in Cleburne in many places near the line of contact. In the north-western belt of the Talladega slates there is another series of more highly siliceous rocks, viz., *quartzites* and *quartzitic conglomerates*, constituting a very considerable part of the mountain ranges, interstratified with the greenish and grayish slates, and well exposed where Talladega Creek makes its way through the Talladega mountain, as well as in all the gaps and along the summits of these mountains. These strata, like the others, have generally a decided dip to the south-east, but along the summits they appear to be nearly horizontal, making occasionally broad flats which support a fine growth of grasses, and are admirable grazing places for sheep. One instance of this flat summit is in the mountain which ends to the south-east in the Pulpit Rock, on the border of Clay and Calhoun.

The quartzites and conglomerates like the slates above mentioned, resemble very strongly some of the strata of undoubted Cambrian age, and it is impossible to resist the conclusion that some of the strata which we have included among the Talladega slates are nothing more than altered Cambrian shales, sandstones, and conglomerates. As yet, however, it has not been possible to discover any fossils in these altered rocks.

In the Kahatchee Hills, and the other localities above named, the sandstones and conglomerates of the Weisner horizon are in appearance almost identical with some of

the conglomerates and quartzites of the Talladega series.

In the other areas of Talladega slates lying further to the south-east, the strata are sometimes more decidedly altered than in the first belt, and are often much more decayed, holding numerous crystals of garnet and tourmaline.

In the *Turkey Heaven Mountain* region in Cleburne, we find a very well defined variety of these semi-crystalline schists consisting in the main of quartz but containing a large percentage of graphite and magnetite. These schists are of a dark slate blue color, with glistening surface, sometimes smooth and rubbing off on the fingers, sometimes hard and sandy. Through the dark blue black mass of the slates pass thin sheets of white quartz, giving the appearance of some of the banded diorites.*

Slates of this formation *impregnated with graphite* are common in many localities. Thus between Millerville and Elias, in Clay county, the soft slates are so highly impregnated with graphite as permit them to be used, in one locality near Millerville, for lubricating purposes. This belt is continued on towards Goodwater, where it is seen at several points in the railroad cuts. To the south-westward the same belt may be followed entirely through Coosa county, and another similar belt parallel with this passes through part of Coosa a short distance north of Rockford.

In the Silver Hill region graphitic slates appear in great force, suggesting by their color the name of one of the gold mines, Blue Hill. The graphite here opposes a very serious obstacle to the profitable working of the gold.

Another well defined variety in the rocks of this form-

*Mr. Brooks has described one of the rocks of this kind, No. 2 of his article.

ation is formed by the *highly fissile blue black slates* resembling roofing slates, which are generally met with along the eastern flank of the Talladega mountain range, a well known occurrence being near Chandlers springs.

Limestones, or rather *dolomites*, have been observed in two positions only in these areas, viz: (1.) On the southeastern flank of the main slate belt of the Talladega Mountain at two localities, viz., (a) near Elder P. O. in the northern part of Clay county, where it is associated with the smooth greenish and gray slates above mentioned, and (b) in Chilton county in the river bluff not far from the mouth of Yellow Leaf creek. In these localities the dolomite is not much altered, but in the other belt (2), in Lee county, the dolomite is in part fully crystalline, white, and like the finest statuary marble, in part however, bluish and gray and less crystalline. These dolomites are closely associated with quartzites.

Near Wright's Mill, four miles from Auburn in Lee county, is the southernmost outcrop of these dolomites, formerly extensively worked for lime burning at the old Echols and Reese quarries. The dolomites occupy a narrow valley about a quarter of a mile broad, with a ridge of slaty quartzites to the northwest, and with *augen-gneiss* both to north-west and south-east.

At this place the rock is gray to blue in color, varying in composition from an almost pure dolomite to a rock containing a good deal of siliceous and micaceous matters. Some miles to the north-east of Wright's Mill is the Lime Kiln of the Chewacla Lime Company, where the dolomite is taken from a large open pit or quarry. Here there is a very large proportion of the white fully crystalline rock, along with some that shows bluish and grayish colors, and is very slightly crystalline. The quarry is in an open field in which there are few, if any, outcrops of the country rock, and so it is impossible to give much information concerning the associations, al-

though, judging by what may be seen further towards the north-east at Springvilla and the new quarries, the same associations prevail as at Wright's Mill, viz., itacolumites or slaty quartzites immediately adjacent to the dolomite, and *augen-gneiss* both to the north-west and to the south-west of the lime belt. Some details concerning the *augen-gneiss* will be found below in connection with what is said about the next series of rocks of this area.

Structure and attitude of the Talladega slates.—As a rule these beds have a dip to the south-east, the exceptions to this being very few.

In some parts of the Talladega Mountain range we find at the summit of the highest ridges, broad areas of nearly horizontal beds of quartzite and conglomerate, and in general the strata of these summits are much less inclined from the horizontal than they are on either flank, and it becomes thus at times impossible to resist the conclusion that some of these ridges are anticlinal arches overturned towards the north-west, the flat rocks at the tops being the crowns of the arches. In the ridge of which the Pulpit Rock is a part, this structure is perhaps better shown than elsewhere. In the interior belts the dip is almost invariably to the south-east. Prof. Tuomey speaks of the dolomite at the Chewacla quarry being nearly horizontal in bedding, but I have been unable to convince myself of this, as the rock is traversed by several joint planes making it very difficult to identify the true bedding plane. And wherever the quartzites with which the dolomite is associated are clearly exposed as at Wright's Mill, and the New Quarry near Springvilla, they are seen to stand nearly vertical, and it is probable that the dolomites also partake of this attitude.

2. ALTERED ROCKS OF IGNEOUS AND UNDETERMINED ORIGIN.

These, in the order of their relative abundance, include

the gneisses and the mica schists, to which are subordinated the granites, diorites and various hornblendic, pyroxenic and chrystolitic rocks occurring as dikes, together with the alteration products of the same, soapstone, talco, serpentine, etc.

These rocks represent more than one geological period, for those which occur as intrusions in the others, must necessarily be younger than the rocks which they traverse. We are not, however, yet in position to make definite classification as to age of these fully crystalline rocks, except in a few cases; we shall therefore limit ourselves to general statements concerning them.

1. The Gneisses.—These in structure vary from nearly massive granitoid rocks to fine grained mica schists. In most cases which have come under my observation, the granite "flat rocks" show traces of cleavage planes nearly perpendicular. Along the borders of these granite-like masses, the schistosity increases and the granite grades into gneiss. The grading of gneiss into mica schist is generally effected as shown below through a series of alternations of the two rocks, each maintaining its own character. The cleavage planes of the gneisses and other schists coincide generally with the structure of the Appalachian region in this state, the strike being in general about north-east and south-west, with slight variations. The dip also is in the majority of cases to the south-east; but there are exceptions, as will be seen below. Thus north-west of the Silver Hill slate belt, as above described, the dip of the strata is almost invariably to the south-east, while to the south-eastward of this belt the variations are more numerous. A *synclinal axis* may be followed easily and almost continuously from the vicinity of Tallassee, in Elmore county, past Walnut Hill in Tallapoosa county, crossing the railroad between Dadeville and Camp Hill; thence north-eastward, leaving Dudleyville to the west; past Thurman, crossing the

railroad a little south of Welch station, and then on towards the Georgia line. An *anticline* may be traced approximately parallel with the line of the Western Railroad from Farrall's Mill, in S. 30, T. 18, R. 25, E., past Wright's Mill, Chewacla Lime Works, Springvalla and thence through S. 7, T. 20, R. 28, E., to the river near the upper factory below West Point. Hornblendic rocks prevail to the north-west and mica schists to the south-east of this anticlinal, and at many points the gradual passage from hornblendic gneisses to mica schists may be perceived. This gradation is usually effected by alternations of the hornblendic rocks with the mica schists in a narrow belt between the two well defined types, and may be observed in sections 6 and 7 of T. 20, R. 28 east, and also near the upper factory above mentioned. Along the river road between West Point and Columbus, another *synclinal* may be observed, a little south of Osanippa (Berlin), and an *anticlinal* between Mechanicsville and Wacoochee, or rather at the latter place. These have not been accurately located further to the west for the reason that the superficial sands, pebbles and other materials of the Lafayette formation cover all the country in that direction, practically limiting obtervations of the underlying crystalline rocks to the drainage valleys, and to a very small part of them.

While the gneisses vary in structure from the granite-like masses to the highly fissile mica schists, they vary on the other hand in composition by the accession of hornblende, through hornblendic gneisses, often with difficulty to be distinguished from diorites, to hornblende schists. It is certain that variations also occur in the prevalence in different areas, of different kinds of mica and different kinds of feldspar, but we have had as yet too little of accurate study of these rocks to put us in position to speak very definitely on these points, except where we have had the microscopic examinations made,

which are given in detail in another part of this report. Within the area of the hornblendic gneisses occur in places massive diorites, resembling granite in structure, and like them of intrusive origin. Under the next head are given some details of the occurrences of these diorites.

In surface distribution, the gneisses, including the hornblendic gneisses with which they so often alternate, occupy (1) a belt lying to the north-west of the Goldville belt of Talladega slates. This we may call the Alexander City gneiss belt, which is practically continuous from the Coosa River nearly to the Georgia line. It holds many areas of "flat rocks" or granites in Coosa county, but in Clay and Randolph counties these granites are generally in the form of isolated masses in the Talladega slates, usually, however, close to the borders of the gneisses.* Towards the north-west the gneiss of this belt passes into a mica schist which very often continues up to the great mountain-forming belt of the Talladega slates, though this is not invariably the case, as for instance near Arbacoochee, in Cleburne county, where the gneiss lies next to the Talladega slates, or with only a narrow belt of the Hillabee or Millerville green schists between. This gneiss belt does not appear to reach to the Georgia line; or if it does, it is in much diminished volume, for beyond Arbacoochee, Hightower, etc., in Cleburne county, the Talladega slates are seen in direct north-eastward continuation of the gneisses.

In this first or Alexander City gneiss belt, there are many occurrences of coarse pegmatitic granite in dikes or veins. These veins are the sources of mica and of kaolin, and are most numerous and promising perhaps in the vicinity of Micaville, Pinetucky and Milner, in Randolph county; but at many points in Cleburne, Clay, Coosa and Chilton, along this belt, the mica has been

*Some of these "granites" are merely massive forms of the gneiss, but in other cases they occur as "dikes."

found in sheets of merchantable size, but in few, if any, of the localities of its occurrence has it been opened up to sufficient depth to be beyond the influence of the weather. Mr. Brewer has given localities and some details concerning these occurrences, and other details will be found in my report for 1874. In Randolph and also in Clay and Chilton, there are old pits where this mica has been worked in ancient times, for in these pits are now growing pine trees a foot or more in diameter. Near Hissop, in Coosa county, and at several points towards the south-west as far as Speed, this pegmatite carries beryls of quality suitable for cutting.

(*2*)The second gneiss-mica schist belt separates the Goldville and Silver Hill slate belts. In Coosa and Tallapoosa counties this belt is tolerably uniform in quality and width, but in Randolph it seems to divide, with Talladega slates between the division, and to break up into somewhat isolated areas in the midst of the Talladega slates. Three of these detached areas may be named, each containing some granite, i. e., one about Gay P. O., another just south and south-west of Wedowee, and a third a little to the north and north-east of Wedowee, the three areas somewhat *en echelon.*

(*3*) The third gneiss belt includes, with the exception of the dolomite belt, Chewacla-Springvilla, above defined, the rest of our crystalline region towards the south-east. In this third belt there are the ordinary gneisses and granites, especially near the north-west border of the belt, but hornblendic gneisses and diorites prevail and give character to the topography, soils, etc. In this last section, so far as I am aware, there are no occurrences of gold, at least in notable quantity.

To the south-west of the Montgomery-West Point Railroad, much of the gneiss assumes the character of *augen-gneiss*, in which certain of the constituents, generally quartz or feldspar, appear in "augen" or "eyes,'

i. e., somewhat elliptical shaped masses from one inch in diameter down. Several descriptions are given of this rock, as well as of the more common varieties, in the notes of Dr. Clements and Mr. Brooks below.

(*2*.) *The Diorites*.—After the gneisses and associated rocks, probably the most widely distributed of the rocks of this region are the diorites, which, as above stated, are often very difficult to distinguish from some of the hornblendic gneisses. The diorites occur as intrusive masses, often occupying long narrow strips in the direction of the strike, but sometimes as rather isolated masses of limited extent in the midst of the gneisses.

A belt of diorite (with hornblende schist in places) may be traced practically without interruption from near Verbena in Chilton county, through Coosa county past Hanover, Mount Olive and Pine Grove into Clay.

Somewhat in continuation of this line, but occurring more in detached masses we find this rock again in the lower part of Clay, while from about Chandler's Springs through Fishhead Valley, past Riddle's Bridge and thence north-eastward towards Wood's Copper Mine in Cleburne, there is another rather continuous outcrop like that of Coosa county.

To the south-eastward of the Silver Hill slate belt, hornblendic rocks are more generally present than in any other part of this section. Many of these are diorites, but the accurate mapping of these has not yet been attempted. The notes of Dr. Clements and Mr. Brooks describe a number of typical diorites from this area.

(*3*.) *The Hillabee, Iwana, or Millerville Green Schists*.—Along the south-eastern border of the main mountain belt of Talladega slates, there is an almost continuous outcrop of a green schists which microscopic examination discovers to be probably an altered eruptive rock. In the report of Mr. Brewer, which precedes, this is

spoken of as the Millerville, Iwana, or Hillabee schist, using the names of localities where it shows in typical form. It may be followed practically without interruption, but with somewhat varying width of outcrop, from Chilton county through Coosa, where it underlies a tolerably wide expanse of country about Stewartsville and Iwana; thence through Clay, about Hollins, Pine Grove, Mountain Meadow, Brownsville, Millerville or Hillabee, Coleta, Chandler's Springs, Fishhead Valley; and on through Cleburne, by Chulafinnee, Arbacoochee, Anna Howe, etc. Beyond Chulafinnee the outcrop narrows down to a small strip. It is widest in Clay and Coosa where it underlies a sort of Flatwoods, as is the case near Chandler's Springs, Coleta, and Hollins, in Clay, and between Iwana and Stewartsville, in Coosa. In fresh condition these rocks are of light green color and are rather massive in structure, and very tough, but on weathering they turn into greenish yellow slates much stained with iron, and then bear a striking resemblance to some of the Talladega slates with which they are in immediate contact. The soil derived from the weathering of these schists is a yellowish or reddish clay with a notable proportion of lime, indicated by the character of the growth which contains a considerable admixture of haw, crab apple and similar lime-loving plants. The manner in which the soil compacts under the wheels of vehicles is also suggestive of lime. When partially decayed, these slates as above stated, have a strong resemblance to sedimentary rocks, and especially to some of the feebly crystalline slates of the Talladega series. This resemblance is particularly strong in the case of some of the more siliceous varieties which imitate very closely some of the conglomerates and siliceous slates of the Talladega. In some of their outcrops they resemble impure slaty limestone, as is the case just below Coleta, in Clay county. In other places of their occurrence they

break up into long, slender and somewhat cylindrical fragments, exceedingly tough and resistant to weathering. The immediate vicinity of Chandler's Springs furnishes an illustration of this phase. The highly schistose and slaty varieties may be seen about Hillabee or Millerville, in Clay county, and particularly at Monroe's Mill close by. The varieties resembling siliceous conglomerate abound along the road leading from Millerville towards Hatchet Creek postoffice, and especially along the flanks of McGhee Mountain. In many places, and particularly where these rocks make a moderately wide belt of country, they form "Flatwoods," with decidedly calcareous soil, supporting a growth of short leaf pine and black jack oaks, with many haws, persimmons, poplars, crab apples and sweet gums interspersed. Such Flatwoods may be seen about Chandler's Springs and between the Springs and Coleta, also for a long distance along the road from Millerville westward towards Hatchet Creek, by Pine Grove and Hollins, and in great force near Iwana postoffice and on to Stewartsville. Below Stewartsville these flatwoods are succeeded by flat, long-leaf pine lands bearing some of the finest timber to be seen in middle Alabama. The siliceous rocks of the Talladega slate formation underlie a great part if not all of these pine lands.

In places the Hillabee schists hold a large percentage of pyrite in crystals disseminated through a siliceous rock. When the proportion of pyrite crystals is large it seems probable that the mineral might be concentrated without too much expense, so as to make it profitable to mine. In most of the cases which I have observed, the rock has a large percentage of quartz grains along with the pyrite. Attempts have been made at several points to mine this pyrite, especially in the vicinity of Hatchet Creek P. O. in Clay county, where it is relatively abundant. A large quantity of it was thrown out of the old

McGhee copper mine many years ago. At C. C. Duke's in S. 17, T, 23, R. 17 in Coosa county, some work has been done towards exposing the vein or seam which bears the pyrite.

Also in section 24, T. 19, R. 7 E., in Clay county, and at the old Montgomery Copper Mine close by, there is a very good show of pyrite. In S. 24 the seam is four to five feet in thickness, while at the Copper Mine it may be greater, for about the mouth of the old shaft there are masses of the pyrite of considerable size. It was impossible for me to see there any exposure of the vein or seam because of the falling in of the old works. In these cases, as in the lower part of Clay and in Coosa, the pyrites is mixed with quartz grains.

Microscopic examination of thin sections of these rocks shows that they are composed of actinolite, epidote, chlorite and zoisite in the main, with some quartz, and they have been named by Dr. Clements and Mr. Brooks Chlorite-epidote schists, Actinolite-epidote schists, Chlorite schists, etc., according to the prevailing ingredient.* In general, the alteration has gone on to such a degree that the determination of the original rock from which they have been derived is difficult, but all agree in thinking that they are result of alteration of some basic eruptive rock. For the present, therefore, we have grouped them together under the name *Hillabee*, from the locality where they are exposed in typical fashion. Some of the gold occurrences in the north-western belt seem to be closely connected with these rocks, as at Chulafinnee, Anna Howe, etc.

(*4.*) *Other Basic Rocks.*—At many points within the gneiss belt occur dikes and isolated masses of pyroxenic, chrysolitic and other basic rocks. These are mostly so much altered at the surface as to make it often very dif-

*See Nos. 38, 39, 40, 4 of Dr. Clements, and Nos. 4, 5, 6 and probably 9 of Mr. Brooks.

ficult to determine what was the original rock, for at the outcrop they appear in the form of chlorite, steatite, serpentine, etc. These occurrences have not been mapped as yet, and I shall call attention only to some of the best known. The notes of Dr. Clements and Mr. Brooks give many interesting details concerning them. In the great gneiss belt lying furthest to the north-west occurrences of these rocks are to be seen at several points; to the north of Goodwater; in a number of places near Flatrock post office, and in Fishhead Valley in Clay. In the next gneiss belt, these rocks occur at several places near the north-western border of the gneiss, e. g., at Robert Goodman's in S. 36, T. 22, R. 2, at Fosheeton and one or two points further north-east in the same line. Then along the north-western border of the Dadeville gneiss belt near its contact with the Silver Hill gold belt, e. g., in R. R. cut just below Dadeville; on Sandy Creek south of Dadeville; seven miles north of Dadeville, and thence in a north-easterly direction by Easton P. O. near Dudleyville; on towards Bosworth, near Slay's Mill in Chambers county. This seems to be a rather connected line of these rocks. At two places there is associated with these rocks along with steatite, chlorite, asbestos, etc., a notable quantity of corundum, occurring in detached masses. These two localities are Robert Goodman's, below Alexander City, and the vicinity of Dudleyville.

Near the Tallapoosa river, a few miles above Tallassee, there is a considerable mass of steatite which has been used by the Indian in the manufacture of pots and vessels of different sorts, the remains or fragments of which are abundant in the vicinity. Another similar locality is in section 35 or 26 of T. 20, R. 23, which may indeed be only another appearance of the same mass of rock. Here are also many fragments of the vessels formed from the soapstone. Of other soapstone localities I may men-

tion the vicinity of Oak Bowery, and S. 8, T. 21, R. 28 in Chambers. In a number of places, in Chambers county particularly, there is a variety of actinolite rock, often containing a good deal of steatite, and this is very generally known as soapstone. It has been quarried at a number of points and used for slabs over graves, for lining the Chewacla lime kilns, etc. One such locality is near Oak Bowery, on the place of Mr. W. P. Spradling, S. 34, T. 21, R. 26. Another is west of Milltown, formerly worked by Mr. Jackson, another at Five Points, worked now by Mr. Jackson's son.

In the upper north-western part of the Crystalline Schists the occurrences of dikes of the basic rocks are not so numerous, though not wanting, as has been shown above. Soapstone has been observed near Idaho Post-office, and at the Old Wood's Copper Mine in Cleburne; and at some other localities, and chlorite schists may be seen near Copper Mine P. O. in Clay, and in Fishhead Valley. The Hillabee Schists are generally considered as having been derived from some form or forms of basic igneous rock, not now determinable because of the alterations which they have undergone.

Mode of Occurrence of the Gold.

From Mr. Brewer's report and from that of Dr. Phillips, it will be seen that a large proportion of the gold-bearing quartz veins are associated with the semi-crystalline slates of the Talladega series, which are of sedimentary origin. These slates have in the past usually been referred to as talcose slates, and hydromica slates. Perhaps the term *talcoid* might be used with propriety, since they have the general look of talcose slates with, however, very little if any magnesia in their compositon. The gold of the Silver Hill belt, of the Goldville, Hog Mountain belt, of the Turkey Heaven Mountains, and of the Talladega Mountain belt occurs in slates of this kind. In many instances intrusive masses of granite or

of diorite appear in close proximity to the gold bearing slates. As an instance of this the Crooked Creek, Goldberg region, may be cited.

A second mode of occurrence of the gold is in association with gneiss, hornblendic gneiss, and diorites, as illustrated in the belt including Pinetucky, Franklin Mines, etc. A third association is with the green schists of the Hillabee type, as at Arbacoochee, Anna Howe, etc. At Arbacoochee, the gold occurs at the junction of these green schists with gneiss, so that the association might be considered with either.

The gold bearing quartz veins are in the great majority of cases what have usually been termed bedded veins or veins of segregation. They are so termed in the report of Mr. Brewer. Prof. G. F. Becker, of the U. S. Geological Survey, has recently made an examination of the gold fields of the Southern Appalachian as far south as Georgia, and while his examinations did not extend actually into Alabama, his descriptions apply with almost equal force to the Alabama fields. In the other states to the north-west of us, however, there seems to be a much larger proportion of the gold associated with the igneous rocks or with the schists derived from them than is the case in Alabama.

Since the report of Mr. Becker upon the Gold Fields of the Southern Appalachians* embodies modern views upon the structure of the rocks, the character of the veins, etc., I have thought it desirable to give below an abstract of some of his conclusions, which appear to me to be possibly applicable to our Alabama measures.

Structure of the Associated Rocks.

In Alabama, as well as in the south-eastern states, the

*Sixteenth Annual Report of the Director of the U. S. Geological Survey.

structure of almost the entire mass of the older rocks is schistose, the strike of the planes of cleavage being generally that of the Appalachian range, or N. 30 deg. to 50 deg. E. Where sedimentary strata occur they too strike in approximately this direction, in consequence of the folding which has built up the range; and as a consequence of this fact, the cleavage of the schists has very often been mistaken for bedding. The dip of these schists is generally towards the south-east, though occasionally, north-west, as well as other abnormal dips, occur. These remarks apply to the more prominent surfaces of schistose cleavage, but observation will generally show that there are schistose partings at a large angle to the most pronounced one, and when the two are about equally developed, their intersection being nearly horizontal, the strikes of each are approximately the same. Occasionally there are other schistose cleavages striking nearly at right angles with the predominant cleavage, but these play a comparatively unimportant part. According to modern views, massive igneous rocks such as granite, as well as stratified rocks, are converted into schists by the development of planes of cleavage by shearing, i. e., "by the sliding of each of the parallel infinitely thin lamellæ, of which the rock may be considered to be made up, upon that next below it, in the same direction and by the same infinitesimal amount," the movement being distributed over an infinite number of surfaces and not reaching the rupturing strain on any one. If the rock is not very uniform in composition, some portions of it may acquire the schistose structure before others, and the resulting schist will show bands or sheets in which different degrees of schistosity will be exhibited. If the deforming movement be carried far enough, fissures will be opened in part of the schist and carunculated surfaces or puckered surfaces will result, whilst other portions of the schist will have

merely flat cleavage surfaces. It is in such unevenly deformed rocks that fissures have opened most widely and veins are most abundant and widest. "Carunculated surfaces are therefore properly regarded as favorable indications by the miners."

Prof. Becker finds proof that the opening of the fissures now filled with ore took place later than the movements which rendered the country schistose, in the fact, among other things, that angular fragments of schist are often enclosed in the quartz; on the other hand the connection of the ore deposits with dikes does not appear to be very close, but coeval on structural grounds, since neither the ore deposits nor the dikes have been greatly disturbed since their formation. The observations of Prof. Becker show that in the great majority of cases the fissures follow the schistose partings somewhat closely though not accurately, showing a certain degree of correspondence between the producing forces of two. Nevertheless the movements were not in general identical in direction. This is shown first in the existence of veins and fissures at various angles to the schistose surfaces, and secondly, in the circumstance that some of the markings produced in the dislocations accompanying the opening of the fissures, do not coincide in direction with the motion which produced the schistosity. Again, where the rocks are schistose and the main ore bodies are intercalated, stringers almost always cut into the walls. From the relation of these stringers to the planes of cleavage of the schists it is inferred with a reasonable degree of certainty that the opening of the fissures has been accomplished by *normal* faulting, while the cleavage of the schists has been the result of *overthrust* or *reverse* faulting; in other words, the movements producing the schistosity and those producing the fissures have been in opposite direction though approximately along the same planes

The Veins.

As has already been said, the ore deposits of Alabama show approximate conformity with the structure of the wall rocks, and for this reason have often been described as bedded veins, and veins of segregation.

As shown by Prof. Becker, the structure with which the deposits are approximately conformable is not stratification, but schistose cleavage, which he also shows to have been produced prior to the movements which opened the fissures, and further, the pressures which opened the vein fissures did not in general coincide in direction with those which had previously produced schistosity. The result of the dislocation was to produce lens-like openings along the main cleavage of the rocks, which were subsequently filled with quartz, forming what he terms lenticular stringers. These stringers are often discontinuous, one dwindling away or disappearing while its place is taken by another in the foot or hanging wall. In many instances diagonal seams may be seen to connect such imbricating stringers, and where the connection cannot actually be seen it is nevertheless inferred to exist, and the conclusion is reached that all the stringers were once united by cracks sufficiently large to permit the passage of solutions. Such connected groups of veins have been termed by Prof. Becker "linked veins," and the association of small fissures, each bearing a lenticular mass of quartz, he calls a *stringer lead.*

While the greater part of our Alabama Gold deposits correspond to the stringer lead type, yet there are numerous small cross fissures. Instances of this are given by Mr. Brewer, for example in describing the occurrences about Goldberg, on Crooked Creek. From what has been said, it will be seen that the stringer leads, while coinciding in general with the schistose structure

of the country, do not coincide with it in detail, and that they are of the nature of true veins, i. e., filling of pre-existing cavities. Instances are also numerous where the veins are attended by impregnations of the country rock to such a degree that it is mined and milled along with the material of the veins themselves.

As stated above, the connection of the ore deposits in Alabama with the dikes cannot be clearly made out, nor can it be said that a satisfactory explanation of the origin of the gold has been reached.

The Placers.

The loose materials carrying the gold in the Southern Appalachians is, according to Prof. Becker, of two kinds, viz., the ordinary stream gravels, and the accumulations of rotten rock in place. To this latter, he proposes to give the name of *saprolite*, as a general term for thoroughly decomposed, earthy, but untransported rock. The celebrated Arbacoochee placers illustrate this term very perfectly.

Mr. Brewer's report above gives full details of the placers which have been worked in Alabama, and nothing further concerning them seems called for here.

B. NOTES ON THE MICROSCOPIC CHARACTERS OF THE ALABAMA CRYSTALLINE OR METAMORPHIC ROCKS.

1. *Notes by Dr. G. W. Hawes.*

The first attempt to study the rocks of Alabama by means of the microscope was made by Prof. Geo. W. Hawes, then of New Haven, Conn., who prepared and described for the geological survey about 25 thin sections of crystalline rocks, sent to him by myself in 1875. I give below a list of the indentifications made by him.

No. 1. Hornblendic mica-schist, Columbus, Ga. (Quartz, orthoclase, hornblende, and biotite.)

No. 2. Graphitic mica-schist, Coosa county. (Quartz, muscovite, and graphite.)

No. 3. Garnetiferous mica-schist, Randolph county. (Quartz, muscovite, biotite, apatite, garnet.)

No. 11. Epidote schist, Clay county. (Epidote, mica, quartz, hornblende.)

No. 13. Hornblende schist, Chilton county. (Hornblende, quartz, orthoclase, oligoclase, ilmenite.)

No. 15. Hornblendyte, Tallapoosa county. (Hornblende, oligoclase, quartz.)

No. 17. Andalusite in hornblendite, Clay county.

No. 17a. Epidosite, Clay county. (Epidote, cyanite, staurolite.)

No. 18. Hornblendyte, Dudleyville, Tallapoosa county. (Hornblende, chlorite, epidote.)

No. 19. Graphitic quartzite, Coosa connty. (Quartz, graphite.)

No. 20. Diorite, Chilton county. (Hornblende, labradorite, titanic, iron, pyrite.)

No. 21. Dolerite, near Auburn, Lee county. (Pyroxene, labradorite, magnetite.)

No. 22. Ossipyte, near Ragan's Mill, Notasulga, Lee county. (Labradorite, chrysolite, hypersthene, titanic iron.)

No. 23. Dolerite, Oak Bowery, Chambers county. (Pyroxene, labradorite, magnetite.)

No. 24. Granulite, Coosa county. (Quartz, feldspar, garnet, epidote.)

No. 25. Hornblendite, Wood's Copper Mine, Cleburne county. (Hornblende, quartz, feldspar.)

During the winter of 1892, Dr. J. Morgan Clements, at that time assistant geologist of the Alabama Survey, made a trip through the territory of our crystalline rocks with the purpose of collecting for microscopic examination typical specimens of the rock varieties most common in that section. The results of his work are given below. Other specimens collected by me were sent to him for identification and study later, in 1894 and 1895, and his report on these follows the article just referred to.

During the summer of 1895, at the request of Mr. C. W. Hayes, of the U. S. Geological Survey, I made a small collection of the crystalline rocks which have been examined by Mr. Alfred Brooks, of the U. S. Geological Survey, whose report appears below. Besides these examinations, Mr. Harry D. Campbell, of Lexington, Va., and Prof. Van Hise, of Madison, Wis., were kind enough to identify for me a number of crystalline rocks, about which there was uncertainty as regarded their origin.

It is the intention to continue these studies of our crystalline rocks, and to publish the result from time to time.

To the notes of Dr. Clements and Mr. Brooks I have added in foot notes such comments as to the associations and distribution of the several varieties described, as have seemed desirable.

2. NOTES ON THE MICROSCOPICAL CHARACTER OF CERTAIN ROCKS FROM NORTH-EAST ALABAMA.

BY

J. MORGAN CLEMENTS.

MADISON, WIS., Dec. 18, 1895.

Dr. E. A. Smith,

State Geologist, Tuscaloosa, Ala.

DEAR SIR :—I send you herewith a brief description of the rocks collected by me during the ten days spent in December, 1892, in the crystalline area of Alabama.

Immediately upon returning from the reconnoissance chips were sent away to be sectioned, but owing to unavoidable delays the sections were not received until nearly six months thereafter. My acceptance of a position elsewhere and entrance upon my new duties almost immediately prevented my completing the work begun on the Alabama Survey.

It has been a source of much regret that other duties have prevented me from sending you ere this the description of the rocks which through your kindness I was enabled to collect.

Very respectfully,

J. MORGAN CLEMENTS.

CONTENTS.

INTRODUCTION.

The rocks examined were collected by me for the Alabama State Survey during ten days spent on a reconnoissance trip in the north-eastern part of the State. It was primarily my object to visit and collect specimens for study from certain igneous rocks observed by Tuomey* E. A. Smith,† and C. H. Hitchcock,‡ and in general to collect specimens of the various crystalline rocks met with, in order that, from a study of the sections, I would be better prepared to undertake the mapping of the area which was contemplated as the work for the following season. The following is really a brief account of the journey, embodying all observations made, with the addition, however, of the notes on the microscopical characters of the rocks collected.

At the end, under the head of conclusions, I have arranged the rocks according to their probable origin, since, in view of the investigation now in progress in the crystalline area, the origin of its rocks is of great importance as indicating the relations to the overlying sedimentaries. It is this line of microscopical inquiry in conjunction with stratigraphical work which will probably be most fruitful in determining whether or not there is an Algonkian series of sediments—more or less metamorphosed—present in Alabama, or whether all the

*Second Biennial report of the State Geologist of Alabama, pp. 51, 61, 63, 1858.

†Observations of Profs. Smith and Hitchcock may be found in their manuscript notes.

‡A hand specimen of the rock mentioned by Prof. Tuomey on p. 51 of his second report, was found in the University collection with his label attached. This was submitted to Prof. Hawes, and by him described as *Ossipyte*: see his No. 22 above. Neither Prof. Hitchcock, Dr. Clements nor myself has succeeded in finding this rock in place.
E. A. S.

crystalline rocks are to be grouped with the Archæan.

Many of the rocks have been affected to a considerable depth by the atmospheric agencies. Frequently they will retain their structure quite perfectly, but when one attempts to collect a specimen the mass crumbles in the grasp. When the rocks have been subjected to active erosion and this thick weathered portion has been removed they will be found to be covered only by a thin altered layer and to compare in freshness with similar rocks from other regions.

An attempt was made to locate all ledges from which specimens was taken, by the sections, townships and ranges, but this proved a failure. In most cases the farmers do not know, or at least were very uncertain as to the section and portion of the section in which they were located.

Notasulga to Ragan's Mill.

Notasulga, where the first stop was made, is built on the light colored sand and gravel of the Lafayette formation, which covers the most of the Coastal Plain of the Southern States. For a mile north of this point the road to Ragan's Mill, Sec. 32, T. 19 N. Range 24 E., passes over this light colored soil. The change is then noticed to the red clayey soil of the crystalline schist area. About ½ mile before reaching the mill, we pass over very rotten mica schist striking N. E. and S. W. and dipping about 45 deg. N. W. Just before reaching the old mill-race, rotten mica schists outcrop again, and have interbedded with them a bed of quite fresh dark green, rather coarse grained schist, Sp. 1, 8 inches thick, striking N. E. S. W. and dipping to the N. W.

Sp. 1. *Amphibolite.*—The hand-specimen shows a vein of quartz which is parallel to the schistosity. Under the microscope the rock is seen to be composed of common green hornblende in interlocking prisms, with a very

small amount of quartz, in grains, associated with it. The hornblende shows marked pleochroism, with the usual absorption, *a.* yellow, *b.* yellowish green, *c.* bluish green, where $c > b > a$. It includes only a few round blebs of quartz. The prisms of hornblende lie with their longer axes in the same general direction, giving a marked schistosity to the rock. There is nothing which gives any clue at all to the origin of the rock.

Several bands of garnetiferous mica-schist are exposed in the banks of the mill-race. The bands strike S. E.-N. W. and dip to the N. W. Numerous small pegmatitic dikes were seen cutting these schists and intersecting each other. One dike of granite, 1½ feet wide, has forced its way in between the strata. Immediately under the bridge the strata are contorted at a point where this granite intrusion shows marked increase in thickness.

Across the race, in the stable yard of Mr. Jones, the schists have a strike N. E.-S. W., with a dip to the N. W., the amount, however, not being determinable, as it was only a surface outcrop. These schists form the knoll upon which the house is built. The schists are here cut by a granite dike, Sp. 32. The rock is light, nearly white, and quite fine grained.

Sp. 2. *Biotite Granite.*—The microscope shows a rock with typical granitic structure and consisting of quartz, microcline and an unstriated feldspar which is presumed to be orthoclase, plagioclase, and biotite as essential constituents, with apatite, garnet, zircon, and rutile present as accessory minerals. As secondary minerals we find epidote and muscovite. The quartz is the ordinary granitic kind, containing both gas and fluid inclusion, the latter frequently with a dancing bubble. Long needles of rutile are rather common in it and zircon is also found enclosed by it. Microcline, which forms the greater part of the rock, is also present in xenomorphic grains and encloses blebs of quartz. It shows the char-

acteristic cross-hatched structure and commonly contains the spindle-shaped microperthitic intergrowths of a triclinic feldspar. Very little orthoclase is present in unstriated grains. Its place seems to have been taken by the microcline. The orthoclase encloses rutile and apatite. Plagioclase is also rather rare in partly autómorphic crystals polysynthetically twinned according to the albite law. Biotite is found in fairly well developed crystals whose contours are, however, at times indented by the other minerals, and whose edges are in places quite ragged. The pleochroism is strong, sections cut parallel to the *c* axis varying from brownish yellow to dark, almost opaque brown. It is beginning to alter on the edges to muscovite. No magnetite was observed in this section. Apatite is in small crystals and is not common. Zircon is rather rare. Rutile occurs in fine needles in the quartz and orthoclase. A light pink garnet without crystal faces was also found in the section. A few garnets are also to be seen macroscopically in the hand specimen. Slightly pleochroic epidote was observed in imperfectly automorphic crystals, usually associated with biotite. All of the minerals are quite fresh, no traces of alteration being observed except in the biotite, which alters to muscovite, and a cloudiness along the edges of the feldspar grains and in cracks traversing them. The order of crystallization is first the accessory minerals, then biotite, plagioclase, microcline, and quartz. The granite shows evidences of dynamic action to a slight degree in the undulatory extinction observed in certain of the quartz grains and in the bending of the twinning lamellæ in some of the feldspars.

Beyond Mr. Jones' house, just before crossing the Sougahatchee Creek, we pass an exposure of rotten micaceous schist with the usual N. E. and S. W. strike and N. W. dip. A somewhat schistose granite rock, Sp. 3 and 4, is seen to form the hill across the creek.

Sp. 3. *Biotite Granite*.—This is macroscopically a light colored, slightly greyish, medium grained rock, showing a banding caused by alternating layers of rock material which are richer and poorer in dark mica.

Under the microscope the rock is seen to be composed of essentially the same minerals as the granite, Sp. 2 above described. Moreover the structure is the same except that a scarcely noticeable parallel arrangement of the mica plates exists, and a general agreement in the long extension of the grains of feldspar and quartz can be seen. In Sp. 3 the mica, which is the same dark brown biotite found in the granite, is in parallel intergrowth in places with a light colored mica muscovite, with strong absorption of the rays vibrating parallel to the cleavage. Neither the accessory rutile needles nor the garnet or epidote is present in the section. The feldspar begins to show alteration, with accompanying production of muscovite. The specimen also shows slight pressure phenomena.

Sp. 4. *Biotite Granite*.—This was collected by Prof. Hitchcock from the same locality, and is identical in every respect with Sp. 3.

I have called this rock a granite in spite of its slightly banded character. It might perhaps be more correctly called a gneissoid granite, for the succession of crystallization of these minerals and the microscopical character show it to be an eruptive rock. The question then arises as to the origin of the laminated structure in it which causes it to simulate a gneiss. The structure is original, for the dynamic action which the rock has undergone is very slight, as shown by the lack of a well developed cataclase structure. It seems reasonable to explain the lamination as the result of differential movement in the original rock magma. The great resemblance between Sp. 3 and 4 and Sp. 2 and their close proximity to each other leads me to suppose, although no connection be-

tween them was observed, that they are portions of the same rock mass. Upon closer study of the occurrence it will probably be found that the mass from which Sp. 3 and 4 were taken is either a great dike, or else a laccolitic mass from which the smaller dikes cutting the schist, such as the one from which Sp. 2 came, were sent out.

According to Tuomey there occurs at Ragan's Mill a dike of gabbro. (2nd Biennial Rep. State Geologist of Ala., 1858, p. 51). This dike was sought for by Hitchcock, but like myself he failed to find it. Hitchcock found, however, near the grist mill what he describes as a very modern looking basaltic rock. (Manuscript notes). At first sight the rock collected by Hitchcock also impressed me as resembling very closely certain young volcanic rocks. As it would be exceedingly interesting if such a rock could be found *in situ* occurring in the Appalachians, an especial search was instituted for it near the site of the mill, for the mill itself no longer exists, but failed to bring it to light. Under the microscope the rock is seen to be a basalt of exactly the same type as that quarried at Niedermendig, Rhenish Prussia, and exported extensively for use in America and elsewhere for millstones, and this was the rock to which it was referred when first seen. Without being able to state positively, it seems to me that the specimens collected by Prof. Hitchcock owe their origin to such an imported millstone, it probably having been broken up into fragments, so that he was not able to observe traces of workmanship upon it.*

The following is a brief description of the rock collected by Hitchcock:

Sp. 5. *Leucite Tephrite.*—This is a fine grained gray vesicular rock. Under the microscope its constituent

*In the summer of 1895, I collected specimens of this rock from the old mill race, and obtained positive proof that it formed part of a millstone imported many years ago by Mr. Ragan. Dr. Clements' conjecture as to its origin is thus verified. E. A. S.

minerals are seen to be augite, olivine (?), biotite, leucite, apatite, and magnetite. Augite occurs in porphyritic minerals and also in very small grains in the groundmass, that is in two generations. In color it is yellow, with a very faint pleochroism. At times it is zonally arranged, with a green pleochroic aegirine-like pyroxene at the center and around it a zone of ordinary augite. It shows the ordinary characters, so frequently described, of basaltic augite. Biotite was present also in porphyritic crystals. Its former presence is determined by its form. Certain paramorphs after it, which retain the biotite form, now are made up of grains of augite and magnetite, the biotite substance having been completely resorbed by the magma. The augite and biotite crystals lie in a fine grained groundmass which consists chiefly of small augite crystals and magnetite, with leucite and plagioclase as feldspathic elements. The leucite shows no optical anomalies in the small crystals here present, but is isotropic. Its outline is marked by the characteristic zonal inclusions of augite, magnetite, and brownish glass. The plagioclase is in small polysynthetically twinned lath-shaped crystals. The magnetite forms well developed crystals of small size. Apatite is present in needles, and in one case a fairly large crystal which was quite full of black interpositions. Numerous grains in the groundmass which are colored yellowish brown by iron hydroxide may be slightly altered olivine, but I could not be sure that they were. Nepheline was sought for in the groundmass but was not found with the microscope, and no microchemical tests were made to prove its presence. Glass was likewise not found, although it is probably present as colorless films between elements forming the groundmass.

Notasulga to Wood's Mill.

A short visit was made to a small quarry to the north.

west of Notasulga, which can be found on the right-hand side of the road about 350 paces in the woods, ¾ mile before reaching Wood's mill. The quarry is abandoned and pretty nearly full of water.

Sp. 6. *Biotite Granite.*—Microscopically the rock is medium grained, gray, and does not show in the hand specimen a gneissoid structure. This is only seen in the rock *en masse* in the quarry, the banding striking N. E. S. W. and dipping 5 deg. S. W. There is a parting which runs parallel with the bands and separates the rock into massive layers. This parting greatly facilitates quarrying.

Under the microscope it is found to be composed of quartz, microcline, orthoclase, plagioclase, biotite, muscovite, and very little magnetite. Apatite and zircon are present as accessory minerals. These minerals all possess the usual characters as described above. The mica is the ordinary brown biotite, showing the absorption, and also muscovite. This latter is frequently seen in parallel intergrowth with the biotite. There is an easily recognizable absorption in it of the rays vibrating parallel to the cleavage, giving it a faint greenish tinge. Some of the minerals show traces of beginning alteration. In the feldspar this slight cloudiness is the beginning of kaolinization. Some calcite, probably infiltrated, was also observed in the section. Undulatory extinction was rare. The rock bears great resemblance microscopically to Sp. 3 and 4 from Ragan's Mill, and it is highly probable that it belongs to the same rock mass.*

Auburn to Mr. Drake's.

One mile north-west of Auburn, in Sec. 19, T. 19 N.,

*To this same rock mass belongs also very probably, the granite described by Mr. Brooks below from 3 miles west of Loachapoka.
E. A. S.

R. 26 E., near Mr, Drake's farm, a quarry in gneiss was visited. The schistosity strikes north-east and south-west and dips 20 deg. south-east.

Sp. 7. *Biotite Gneiss*.—A fine grained dark gray schistose rock very rich in biotite. The microscope shows quartz, plagioclase, orthoclase, biotite, muscovite, and magnetite to be the chief constituents. As accessory minerals garnet, zircon and thulite were observed. The minerals quartz, feldspar and mica are in grains and ragged fragments, and consequently show no well defined order of crystallization. The mica lies between other minerals with well marked parallelism of the long extension of its plates, and gives the rock its schistose structure. Zircon is included in the biotite, and the biotite immediately surrounding it has a very much stronger absorption than elsewhere. A few small crystals of rose-colored manganiferous zoisite—thulite—were found. One was seen included in biotite, and like the zircon surrounded by a pleochroic court. The remaining minerals present their ordinary characters. The rock is quite fresh, slight kaolinization of the feldspar being the only alternation which is shown. It has, however, undergone considerable crushing, to judge from the bending of the mica and undulatory extinction in the minerals. This has even gone far enough to produce an imperfect cataclistic structure. Nothing could be seen indicating the mode of origin of the gneiss, though the crushing might lead one to suppose that it was a metamorphosed eruptive, perhaps originally a biotite granite.

Auburn to Wright's Mill.

A search was made along the road running towards Wright's Mill, south-east of Auburn, for a dike of diabase observed by Dr. Smith, and found about three miles from

the town. I was unable to find the dike and get its relation. The following is a description of the hand specimen collected by Dr. Smith :*

Sp. 8. *Diabase.*—A medium grained dark gray rock, showing macroscopically the arrangement of the feldspar laths. It alters to a light brown product which covers part of the specimen with a thin crust. The rock is a typical diabase, with a beautifully developed ophitic structure. It is composed of plagioclase, quartz, augite, some greenish brown mica, and titaniferous magnetite. The plagioclase is in automorphic lath-shaped crystals and predominates in the section. The angular interspaces between these crystals are filled with the augite, magnetite, and ilmenite. The feldspar is quite fresh, and is twinned both according to the albite and carlsbad laws. Measurements of the extinction angles against the twinning planes gave angles varying from 25 deg. to 36 deg., showing it to be a variety of labradorite. The augite, twinned according to the usual law, is found in xenomorphic crystals between the feldspars. It is light yellowish in color and quite fresh. At times a beginning alteration to a greenish chloritic substance is seen around the edges. A small amount of diallagic augite in small grains has in some cases been almost entirely changed to this substance. The greenish alteration product has a very finely fibrous structure, and seems to be due to a process of serpentinization rather than to uralitization. This also fills some of the angular spaces in the rock, and may indicate total alteration at such places of the originally present augite. No olivine is present. Only a small amount of quartz was observed, and it was in micropegmatitic intergrowth with the feld-

*This is the same rock as that identified by Dr. Hawes as Dolerite, No. 21 above. At present the name dolerite is applied to the more recent and diabase to the older eruptives of similar composition.
E. A. S.

spar, this forming the last product of the crystallization. It fills in a few of the angular interspaces. There is not enough present to cause the rock to be called a quartz diabase. Considerable leucoxene, the alteration product of ilmenite was observed around the iron ore. Some secondary crystals of iron pyrites were also found.

About half way between Auburn and Wright's Mill we cross an outcrop on the top of a hill of quartz-schist.

Sp. 9. *Quartz-schist.*—A white, very fine grained rock, almost novaculitic in texture. It weathers slightly and the weathered surface is tinged red. The schistosity of the rock is marked by the presence of plates of muscovite lying parallel to each other. Under the microscope the rock is seen to be composed chiefly of interlocking grains of quartz. Feldspar in similar grains which show up best when altered, and muscovite in parallel leaves are common. A few rutile needles, zircon crystals, and some iron pyrites are the only other minerals present.

Just before reaching Wright's Mill we pass an outcrop, striking north-east and south-west across the road, of augen gneiss, Sp. 10, which, when very much altered, looks like talcose mica-schist, Sp. 11. The same rock outcrops at the mill in the bed and banks of Chewacla Creek. In the creek bed, just above the mill, we find a thinly bedded finer grained variety, Sp. 13, interbedded with a commoner variety like Sp. 12, which is in its turn merely a finer grained variety of Sp. 10. It is highly probable that the thin bed is only a portion developed along a shearing plane. The strike of the rocks as taken on the contact between the finer and coarser grained variety, Sp. 13 and 12, is N. E.–S. W., with a dip of 60 deg. S. E. These rocks are especially interesting, as showing so clearly the origin of their present structure.

Sp. 10. *Biotite-gneiss.*—Probably derived by dynamo-

metamorphic action from an original biotite granite. Macroscopically it is a typical "augen" biotite gneiss, with a well marked oval augen around which the mica layers bend.

Under the microscope the eyes are composed of feldspar, both polysynthetically twinned and an unstriated kind, quartz, and biotite. The association is granitic, the biotite and triclinic feldspar showing the best development. All the minerals are very fresh. The feldspar is full of minute automorphic crystals of epidote, and zoisite, and contains also small plates of muscovite. The feldspar substance between these minerals is perfectly fresh, showing no trace whatever of alteration. The feldspar shows only slight undulatory extinction. The quartz between the feldspar is, however, already crushed, and is present as an interlocking mosaic. Surrounding the eye there is a zone of varying width composed essentially of minute brown biotite scales with a few larger biotite and muscovite plates lying in a mosaic of crushed quartz and feldspar. Imbedded in the mica are large sphene and epidote crystals. In one case a brown allanite crystal was observed surrounded by epidote, as described by Lacroix* from several localities, and by Hobbs† from the Ilchester granites of Maryland. The sphene and epidote crystals lie with their long extension parallel to the schistosity of the rock. Also a little pink garnet was seen. These and the mica are evidently secondary. They show no sign of crushing. In this biotitic portion there are also minute eyes formed of single oval feldspar crystals surrounded by a mosaic of

*Contributions a l'étude des gneiss a pyroxene et des roches a wernerite. Bull. de la Soc. francaise de Mineralogie, tome XII, No. 4, April, 1889.

†On the Paragenesis of Allanite and Epidote as Rock-forming Minerals, by Wm. H. Hobbs. Johns Hopkins Univ. Circulars, No. 65, April, 1888; Am. Journ. Sci., Vol. 38, Sept., 1889, pp. 223-228; Tch. Min. Pet. Mit., Vol. 11, 1889, p. 1.

small grains of feldspar ground from the large crystals by crushing. The quartz seems in all cases to have been ground down to what we may call a miscrocopical powder, so fine are the grains at times, and this forms the most of the material in which the biotite flakes lie. The specimen shows the phenomena accompanying crushing and shearing most beautifully. The crushing of the quartz is especially well shown. From a large grain showing undulatory extinction the process can be traced to the next stage, where the grain is separated along lines perpendicular to the direction of schistosity. These various edges and also the ends around the outer edges and corners are then rubbed to a finely powdered mosaic of quartz, and in the last stage we have none of the original quartz left in large grains. The feldspar likewise is crushed, but it is usually first rounded by the grinding down of the corners, reducing it to a more or less oval outline. It is also frequently pulled apart and the cracks, extending perpendicular to the direction of movement, have been filled with quartz. Judging from the eyes, which apparently represent the original rock, this biotite gneiss seems to have resulted from the intense crushing of a biotite granite.

Sp. 11. *Biotite-gneiss.* This is a very much altered phase of the above. In it muscovite forms the greater part of the rock, and there is a great deal of ilmenite in well developed hexagonal plates. No epidote and very little sphene is present.

Sp. 12. *Biotite-gneiss.* This is a somewhat finer grained modification of Sp. 10. Instead of epidote we have, however, the rose colored manganiferous zoisite—thulite—appearing in rounded prismatic crystals. It is always surrounded by a narrow zone of clear white zoisite. The minerals have not in all cases exactly the same orientation, the extinction varying very slightly in

the two zones. The thulite has even a lower polarization color than the zoisite, appearing almost isotropic. The occurrence of thulite in biotite-gneiss, noted also in Sp. 7, has, as far as I know, not been mentioned before. Its zonal structure with zoisite is especially interesting. The manganese present in the rock having been used up, the mineral continued to grow by the addition of the zoisite molecule. This zonal structure of the zoisite and thulite may be compared to that described by Lacroix and Hobbs* in the case of allanite and epidote intergrowths. Apatite is present in a few crystals.

Sp. 13. *Biotite-gneiss*, does not differ from No. 12 except in that it is a trifle finer grained and contains rather more muscovite.†

Below the mill there are outcrops in the creek under the bridge and along the road beyond the bridge of a pinkish quartz-schist. I was not sure of the true bedding.

Sp. 14. *Quartz-schist*.—This quartz-schist is almost exactly like Sp. 9, showing, however, a greater degree of alteration. The muscovite is not in such large flakes as in the last specimen, and in general the rock is somewhat coarser grained.

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* l. c.

†The augen-gneiss (biotite-gneiss) here desribed, numbers 10, 11, 12, and 13, occupies a belt four or five miles in width, that may be followed from the vicinity of Auburn northeastward to the Chattahoochee river, where its northern boundary is a little north of Mechanicsville, and its southern limit to the south of Wacoochee creek. In all this belt the several phases in the atmospheric decay of rock may be followed out.

In one stage the result of the alteration resembles very strongly a talcoid mica schist, such as is mentioned by Dr. Clements; this in turn passes into a purple or reddish clays somewhat like the clays characteristic of the Tuscaloosa formation of the Cretaceous.

The dolomite and quartzites of the Chewacla belt occupy a place in the midst of these gneisses, the dip of the gneiss being in both directions from the dolomite belt as though it were upon an anticlinal fold.

Mr. Brooks has also described specimens of the same rock from the same locality, Nos. 15 and 16. E. A. S.

Lafayette to Oakbowery.

Near Mr. Bledsoe's, Sec. 35, T. 22 N., R. 26 E., S. W. of Lafayette on the road to Oakbowery, a mass of rock is exposed striking across the road.

Sp. 15. *Diorite.*—This rock is dark gray, coarse grained, and imperfectly schistose. The minerals forming it are common green hornblende, pyroxene, feldspar, sphene, epidote, and magnetite. These show the usual characters of such minerals. The amphibole is perfectly compact and occurs in grains rather than in crystals. It shows a strong pleochroism, *c*. deep blue green, *b*. yellowish green, *a*. yellow. The pyroxene is a green malacolitic pyroxene, with scarcely noticeable pleochroism from light green to a slightly yellowish tinge of green. It is not present in any better developed forms than the amphibole. It is found in parallel intergrowths with, and also included in, the hornblende. Along the edges it is in places seen to be slightly fibrous, but no other trace of alteration was observed. Careful search was made for evidence of the secondary nature of the hornblende, that is, that it was the result of the alteration of a pyroxene, as has been so frequently described. Its relations to the green pyroxene, including it, seem to favor the idea of its formation from it, the included pyroxene grain representing an unaltered core. No proof of this could be found. The almost perfect freshness of the minerals is itself against it. I could only come to the conclusion that the amphibole and pyroxene are both original.

Both plagioclase and orthoclase are present, the former predominating. Neither possesses crystal outlines, though the plagioclase approaches automorphism most closely. Quartz is present in very small quantity in xenomorphic grains. Sphene is present in numerous small rhombs included in all of the other minerals. Mag-

netite occurs in a few rare grains. The extinction in all of the minerals is sharp, indicating a total absence of dynamic action. The epidote is of quite a different character from what has usually been observed. It is not found in crystals, but as a fringe or zone between the feldspar and hornblende. This fringe is not composed, however, solely of epidote, as is the case in the zone described by Williams,* but of epidote micropegmatitically intergrown with a clear white mineral of rather low single and double refraction. This mineral penetrates the epidote in curving rods, which branch, giving V shaped forms, and have in cross section rounded or irregularly long oval outlines. By changing the focus of the instrument the rods can be followed as they curve and run out without any break to join the feldspar, to which they evidently belong, since they extinguish with the feldspar. The feldspar forms perhaps one-third of the entire mass of the fringe. The epidote has in hand specimen a green color, and under the microscope a greenish yellow tinge without marked pleochroism. It has the high single and double refraction and rough surface of epidote, but no crystal outline. In no case could a figure be obtained in convergent light, probably owing to interference of the intergrown feldspar. No cleavage was observed. In fact, while the statement has been made that the mineral is epidote, no absolute proof can be brought forward to show that it is—no separation and chemical analyses as yet having been made of it. The contact between the epidote and hornblende is fairly sharp. The epidote is at times more or less surrounded by hornblende, but the immediate contact line is sharp.

A case like this was figured by Hobbs† from a gabbro

*The Gabbros and Associated Hornblende Rocks of Baltimore, Maryland, G. H. Williams, Bull. 28 U. S. Geol. Sur., 1886, p. 32.

†Some Metamorphosed Eruptives of Maryland, by Wm. H. Hobbs. Trans. Wis. Acad. Sci., Arts & Letters, Vol. 8, 1890, Fig. 1, p. 157.

diorite from Ilchester, Maryland. The micropegmatitic intergrowth, however, is not mentioned in the text, and but imperfectly represented in the figure. Through the kindness of Mr. Hobbs I was enabled to examine the section figured, and was thus able to satisfy myself of the similarity of the two occurrences, the one from Alabama being a much more perfect case, and the rock in which it occurs being far fresher than the Maryland specimen. In the article referred to the conclusion seems to be that, as suggested by Prof. Rosenbusch, "the mineral is amphibole in thin scales, the high colors resulting from intercalated films of air." This explanation could not be considered at all for the Alabama occurrence, as the mineral is seen to be perfectly compact and occupying the entire thickness of the section. However, as showing an excuse for the suggestion of the hornblende nature of the mineral, it may be mentioned that I found in one case, in Sp. 15, a micropegmatitic intergrowth of feldspar and hornblende on the edge of a large hornblende crystal, which bears a great resemblance in certain positions to the epidote. As soon, however, as the stage was revolved, the marked emphibole pleochroism became apparent, and agreed perfectly with that of the main mass of the crystal, and the cleavage conld be followed extending from the compact main crystal through the micropegmatitic portion. Moreover the interference colors are not so high as are those of the epidote.

In the cases of the epidote occurrences cited above by Williams and Hobbs (1. c.), they have been explained as reactionary rims between the feldspar and hornblende. Both rocks from which they have been derived have been much altered, and have clearly been derived from other rocks by dynamo-metamorphism. The one I have before me is, as above stated, perfectly fresh. Moreover, it has not been subjected to dynamic action, as is shown by the sharp extinction of all the mineral constituents. The

position of the epidote proves it to be dependent for its origin upon the feldspar and hornblende. No evidence can be found in this specimen to support the view that the fringe was secondarily formed by a reaction between the feldspar and hornblende as a result of metamorphic action, however, for the rock has apparently undergone no such metamorphism. Since there is an absence of proof of its secondary nature, may we not, with some degree of probability at least, consider this micropegmatitic epidote fringe to be due to a somewhat similar process and condition as that existing during the formation of the well known micropegmatitic intergrowth so frequently seen around feldspars in the acid porphyries, the reaction upon each other of the feldspar and hornblende molecules remaining uncrystallized at a certain time resulting in a mineral of intermediate composition, the epidote, penetrated by the fresh clear rods of feldspar.

At the foot of the hill just before reaching Mr. Andrews's house, there outcrops on the right of the road, forming a small elevation, a coarsely granular rock, Sp. 17. This is also seen on the opposite side of the road outcropping in several small knolls, the general trend of the rock mass as indicated by the series of knolls being S. E.–N. W. Sp. 18 was taken from one of the knolls right by the negro cabin. As we ascend the hill upon which Mr. Andrews's house stands, we pass over light greenish, rather fine grained schist, Sp. 15, with schistosity striking S. E.–N. W. It is cut by six dikes, Sp. 19, from six inches to fifteen feet in width, which are very much altered, and now consist for the most part of chlorite. Prof. Tuomey says of the exposures:* "Near Mr. Andrews's house, vast and rugged masses of hornblende passing into soapstone are found protruding above the surface and not far from the house

*2d Biennial Report of the State Geologist, 1858, p. 61.

a trap dyke crosses the road, with which I found associated magnetic iron but not in great quantity."

Sp. 16. *Amphibolite* (*Hornblende-schist*).—This is a moderately fine grained light green schistose rock composed of common green hornblende, with magnetite inclusions in small quantity. No quartz or feldspar is present. The amphibole shows moderately strong pleochroism from light green to yellowish white. The extinction is sharp and the angle measured against the prismatic cleavage is low, the maximum of several measurements being 13 deg. A few of the crystals are colorless at one end and green at the other. Such crystals possess, however, the same optical characters throughout. Where the magnetite occurs it is always fresh. The rock in no wise indicates the manner of its origin or from what derived. It resembles very much Sp. 28 and 29 from West Point, Ga.

Cutting this schist we find, as first stated, Sp. 19, but as this is merely an altered phase of Sp. 18 and 17, they will all be described together and the process of alteration traced out. Although the large masses from which Sp. 17 and 18 were taken were not observed in contact with the schist, we may reasonably conclude, from the fact that they are igneous rocks, and the same as Sp. 19 which does cut the schist, that they would bear the same relations to it, if the rock was sufficiently exposed to allow the relations to be discovered.

Sp. 17, 18 and 19. *Hornblende Olivine Rock* (*Cortlandite*).—This is a coarse grained rock with dark green color, which upon weathering is covered wfth a ferruginous crust. It is a granular aggregate of hornblende, olivine, pleonaste, and magnetite. The hornblende differs from that usually found in such rocks in that it is a very light green, so that in thin sections it appears almost colorless, whereas in the rocks for which Williams*

*Peridotites of the Cortland Series, by G. H. Williams, Am. Journ. Sci., iii, vol. 31, 1886, p. 30

proposed the name *cortlandite* the hornblende was the brown strongly pleochroic variety. The hornblende angle and other characters prevent its being mistaken for a pyroxene. It is present in partially automorphic long prismatic individuals and is quite free from inclusions, only in a few cases containing magnetite and minute brownish plates. The olivine is in large grains between the hornblende crystals, and is for the most part altered to yellowish serpentine. Grains of unaltered fresh olivine still remain scattered through the serpentine. It contains a good many magnetite inclusions and also grains of green spinel. The light green isotropic mineral which is present in considerable quantity in irregular grains throughout the rock is a spinel and is presumed to be the iron-magnesia aluminate, pleonaste. It is usually associated with the magnetite, and is frequently seen forming a narrow rim completely or partially encircling it. This also contains numerous small crystals of magnetite. Magnetite is present in large crystals scattered through the rock, besides that enclosed in the other minerals. The secondary products are serpentine, chlorite, and calcite. The amphibole alters along cleavage lines and fractures to serpentine, and in places also to a chloritic mineral which is light green for the ray vibrating parallel to the cleavage, and yellow perpendicular thereto. The olivine alters to the characteristic serpentine with mesh structure.

Of considerable interest is the alteration which the green spinel undergoes. It shows in places an imperfect octahedral cleavage. Along these and fracture lines and around the edges it slightly alters to a white to brownish yellow substance in which still remain the magnetite crystals which are included in the fresh mineral. This substance by high power appears in places somewhat fibrous and seems to have at times a low polarization color and at others to be isotropic. The doubly refract-

ing portion is presumed to be serpentine, a product which might readily be formed from such a ferro-magnesian alumniate. The isotropic portion is not determinable. So far as I can learn, no such alteration has ever been described for pleonaste in any rock. The spinels are usually described as perfectly fresh in all rocks in which they occur. It is one of the most resistant of minerals, and in such rocks remains perfectly fresh after the other minerals have altered, Here, however, we have it beginning to alter, even before the olivine has completely disappeared. Moreover, in Sp. 19, the most altered phase of the rock, the spinel is quite fresh. It would appear to be due perhaps to some special cause acting in the larger dike alone, The alteration is best seen in Sp. 17, and there I believe no one can be in doubt as to its being a true alteration. In Sp. 18 it is not quite so far advanced. Shepard mentions a partial pseadomorph of steatite after a green spinel, containing chromium, from N. Carolina.*

Sp. 20. *Amphibolite* (*Hornblende-schist*). Immediately after crossing the first large brook beyond Mr. Andrews's I collected a specimen from a rock outcropping in a small mass to the right of the road. Could get no good strike of schistosity. The rock is green, schistose, and medium grained. Under the microscope it is seen to be identical in character in fresh condition with the preceding amphibolite, Sp. 16. As it begins to alter, however, there is a change in the character of the rock. The amphibolite begins to bleach, the bleaching beginning along the edges. As a result of this bleaching we have an amphibole formed which is very much lighter in character than the original, and occurs not in compact masses but in more or less fibrous crystals with green color. It shows very slight or no pleochroism and

*C. U. Shepard: Corundum of N. Carolina and Georgia. Am. J. Sci. IV. 113, 1872.

possesses the characters of actinolite. Grains of calcite and magnetite are observed intermingled with this secondary amphibole, and are looked upon as products of the decomposition of the common hornblende. The magnetite has collected in aggregates of varying size, and is usually surrounded by the actinolite, mixed with grains of calcite.

At Mr. Joel Harris's Sec. 4 or 9, T. 20 N., R. 26 E., I collected Sp. 21 from the brow of the hill back of the house.

Sp. 21. *Diorite*. This is a black schistose rock, which upon examination proves to be diorite. The hornblende is the common compact green variety, strongly pleochroic, *c*. bluish green, *b*. yellowish green, *a*. light yellow, and occurring in thick forms approaching grains. It has all the appearance of an original constituent. The feldspar, which is a plagioclase, is without crystallographic contours. This is accompanied by a few unstriated grains supposed to be orthoclase. All of the feldspar is very fresh, showing in a few cases beginning cloudiness. Very little quartz is present. Epidote is found in a number of large crystals. Of all the minerals it has the best crystallographic outlines, in every case one or more crystal faces being developed. Some magnetite is present included in all other minerals.

Sp. 22. *Diorite*. From large boulders in situ in Mr. Joel Harris' pasture. This is the same as above except that the epidote is wanting. The extinction in both of these sections is sharp, indicating total absence of orogenic pressure. The schistosity is given to them by the general parallelism of the hornblende prisms, causing the rock to cleave readily in a certain direction.

Lafayette to B. F. Frazier's.

Going west from Lafayette upon the Dudleyville road we pass, just before crossing the large branch of the

Hoodlethlocco creek, about a mile from town, an outcrop of a green dioritic rock like Sp. 15 and 21. This is weathered to a depth of several feet, the weathered product being a yellowish brown porous rock through which are scattered black spots of limonite and in some cases glistening grains of quartz. This alteration product is quite common along the road from Lafayette to Oakbowery and to Dudleyville, but this was the first time it was seen in connection with even a fairly fresh rock. Usually only the porous brown alteration product remains. Near B. F. Frazier's, the old Holloway place, a low outcrop of quite rotten hornblende olivine rock, Sp. 23, was visited. This I was told had been used for making mantels in a few cases by some of the people living there.

Sp. 23. *Hornblende Olivine Rock* (*Cortlandtite*). This rock is of a dark green color, coarse grained, with the brown colored hornblende appearing in large porphyritic crystals, each surrounded by a narrow zone of lighter colored mineral.

Under the microscope it consists chiefly of large crystals of hornblende, grains of olivine and magnetite as primary minerals, and actinolite, talc, and chlorite as secondary products. The hornblende, in large plates, having macroscopically a brownish or bronze color, shows microscopically a yellowish to yellowish green tinge, and is very weakly pleochroic. It contains olivine and magnetite inclusions. It bleaches around the edges and forms lighter colored green amphibole. The alteration of the compact hornblende to the fibrous actinolite is very beautifully shown. With the alteration there follows the reduction of the extinction angle from 20° in the large plates to 18° in the fibrous actinolite surrounding it. It also alters to talc. The olivine is in large grains and contains magnetite and also some hornblende inclusions. It is remarkably fresh, beginning to

alter along the edges very slightly. The magnetite is in considerable quantity in grains, and is included by all original minerals. As can be readily seen, the fibrous hornblende is formed from the compact variety. There is a large amount of this present. Talc is frequently found surrounding the hornblende and in the large plates also penetrates it along fissures. In the fissures it contains magnetite, just as the serpentine veins in olivine do, and appears to be without doubt secondary after the hornblende. There is a large amount of it present in the rock. Chlorite is found, but in rather small quantity.

Perhaps this is the rock to which Tuomey refers when he states 'that about seven miles west of Lafayette a trap dike comes to the surface.'* This is about that distance from the town, but I strongly suspect that he observed some of the dark schistose dioritic rocks like that which I mentioned above, and termed it a dike, as farther on he speaks of this dipping to the southeast. The rock from which the cortlandite came is perfectly massive. On the same page he speaks of the same series of rocks outcropping on the road to West Point, Ga. I passed the brown, rotton, weathered product of the diorites outcropping on the road to West Point also, but but no massive dike rocks. This brown alteration product is quite common around Lafayette.

West Point, Ga.

While waiting for a train here I visited a place where, according to Tuomey,† as near as I could judge from the location given, an interesting trap dike was to be seen. I collected several specimens of the rock outcropping, and it may be well to describe the section, as the

†Second Biennial Report of the State Geologist of Alabama, 1858, p. 63.

*Second Biennial Report of the State Geologist of Alabama, 1858, p. 63.

same rock will probably be traced over into the Alabama territory.

In the first deep railroad cut on the east side of the Chattahoochee river there is an excellent exposure of crystalline rocks. They possess a certain degree of schistosity, the strike of which is uniformly NE–SW and the dip to the NW 60°. The rocks are very much altered, though some specimens were obtained which were quite fresh.

Sp. 24. *Diorite.* This is an especially coarse grained rock, and under the microscope is seen to be composed of common green hornblende and plagioclase, with small amounts of orthoclase, quartz, and magnetite. The minerals are xenomorphic, but the plagioclase seems to approach nearer to being automorphic than any of the rest.

Sp. 25. *Diorite.* This is a trifle finer grained than the preceding and is composed of the same common green hornblende, plagioclase, very little orthoclase and quartz, considerable apatite in round grains, and some pink garnet and also magnetite. The garnet is automorphic. None of the other minerals show crystallographic boundaries. The minerals are very fresh under the microscope. The magnetite is beginning to alter, and colors the adjacent minerals with yellowish brown iron hydroxide.

Sp. 26 represents an advanced stage of alteration of rocks similar to 25, but containing a good deal of quartz, the only mineral now remaining. Otherwise it is a mere network of isotropic brown iron hydroxide.

Sp. 27 is the most advanced stage of similar rock. No mineral is seen at all in this, the quartz having failed in the original or else having been washed out, leaving merely the porous clayey ochreous mass.

Sp. 28. *Amphibolite* (*Hornblende-schist*).—To the east of the coarse diorites there is exposed for nearly 150 feet a rock which is without stratification or marked schistosity. It is found mostly in irregular blocks separated by a sandy decomposition product. The rock itself has a rough sandy feeling. It is light green in color with a tinge of yellow. Under the microscope the rock is found to be made up of common green hornblende in irregular grains and prismatic crystals, and a monoclinic amphibole, colorless in thin section, which at times is intergrown with hornblende. A few grains of quartz were observed between the amphiboles. The rock is very fresh, and the decomposition seems to be merely a loosening of the grains, which allows the hornblende crystals to fall apart very readily. The two sections are very thick. It would be interesting to find out the relations of this rock to the rocks represented by Sp. 29 and 30, and thus determine its origin. I am unable to tell from the sections how the rock originated.

There occur interesting rocks. Sp. 29 and 30, exposed in numerous blocks on the surface above the railroad cut but not outcropping in the cut itself. These blocks are scattered along a ridge having its long direction extending approximately north-east and south-west.

Sp. 29. *Augite Norite or Hyperite.*—This is an exceedingly tough, medium grained green rock, which under the microscope has as constituents hypersthene, augite, hornblende, plagioclase, and magnetite. Hypersthene is in larger proportion than any other mineral and is present in short prismatic individuals without terminal faces. It is colored quite deeply and shows its characteristic pleochroism, *a*. red, *b*. yellowish red, *c*, green. Some but not all the crystals contain the reddish brown platy inclusions which are so frequently found in hypersthene. Fibrous green diallage is present in about equal quantity with the hypersthene. It is xenomorphic, and

some of its crystals contain brown inclusions. It may be easily distinguished from the hypersthene by its high extinction angle and lack of pleochroism. Both the hypersthene and diallage have a mottled appearance between crossed nicols. This is especially marked in the diallage. It is seen to be due to included microlites with light green tinge, which from their high extinction angle are supposed to be some pyroxene mineral. Owing to the great thickness of the slide and strong color of the enclosing mineral, the difficulty of determining the microlites is greatly increased.

Hornblende is present in very small quantity. It occurs in a partial rim around the pyroxene. It is light green in color, compact, and apparently an original mineral. The plagioclase is found in very small quantity and forms xenomorphic grains filling in the angles. In a few places larger plates of it enclose the hypersthene individuals, giving a poikilitic structure. It also contains numerous light greenish undeterminable microlites. No iron ores are present; all of the iron present in the original magma having apparently been used in coloring the various minerals. All of the minerals are very fresh. The structure of the rock is granular. The above described rock bears remarkable resemblance to some of those described by Williams* from the Cortlandt series of New York.

Sp. 30. *Pyroxene Hornblende Rock.*—Macroscopically this is quite similar to the preceding, but one can readily see that there is a larger proportion of the light green hornblende present. The components of the rock are hornblende, augite and magnetite. The hornblende is in zenomorphic individuals, is compact, and is a light green variety of the common hornblende. It is original. The augite occurs in large plates enclosing small hornblende individuals. It is also compact, of a pink color,

*Am. Journ. Sci., iii, Vol. 33, 1887, p. 193.

and with very slight pleochroism. Both the pyroxene and hornblende contain numerous inclusions of magnetite. In addition to these inclusions the magnetite also occurs in large crystals scattered through the rock. No feldspathic mineral is present, and the structure is granular. This is a peculiar facies probably of the same magma from wnich the norite is separated, as would appear from their intimate association.

These are exceedingly tough rocks, forming apparently the ridge extending north-east from the railroad cut. Along this ridge these boulders are found scattered in intimate association, though the relations of the one to the other could not be observed. There are several pits which have been sunk in search of copper at various points on the ridge, and it was probably from one of these that Tuomey collected the serpentine, Sp. 31. The sides of the pits have now caved in, or else have been otherwise filled with debris.

Sp. 31. *Serpentine.*—Macroscopically the rock is greenish brown and very dense. Under the microscope it is so completely altered that a spinel and magnetite are the only original minerals left. Some secondary calcite is present and also a chlorite mineral. The spinel is not as green as that described from the Cortlandtites, but has a decided brownish tinge, and is probably quite close to picotite. I am unable to tell from the rock what might have been the constituents of which it was originally composed.

The ridge formed by the norite and pyroxene-amphibole rock was followed for three-fourths of a mile and then died out. I continued on to the river hoping to find these rocks outcropping in the banks or bed, but did not find them. The river where I touched it was being channeled and jettied, and the blasting had brought fresh rock from the river bed to the surface. A couple of specimens, 32 and 33, were taken.

Sp. 32. *Biotite Hornblende Gneiss.*—This is a medium grained gray well laminated rock. The micaceous bands give it its marked gneissoid structure. It is composed of common green hornblende, which predominates, brown biotite, pleochroic from an almost opaque chocolate brown to pale yellow, plagioclase, doubtfully orthoclase, quartz, sphene, pleochroic from yellow to pink, apatite, zoisite, and magnetite. Calcite is present in grains and has not the appearance of an infiltration or secondary product. All of the above minerals show their common characters. Undulatory extinction and bent twinning lamellae were common.

Sp. 33. *Diorite.*—This is a medium grained black rock with granular structure. It is composed of hornblende, biotite, plagioclase, orthoclase, quartz, spene, and magnetite. The hornblende is dark green, compact, and strongly pleochroic. It occurs in grains. Biotite forms regular plates with strong absorption from yellow for rays vibrating parallel to cleavage to chocolate brown for those perpendicular thereto. It is not present in very large quantity. Plagioclase is the prevailing white silicate. It is xenomorphic and contains numerous minute plates of rounded and oval shapes, which are transparent with a brownish color. A few rare unstriated feldspar crystals (orthoclase) were observed. Quartz is present in a few grains. Sphene is scarce. There is quite a good deal of magnetite.

Sp. 34. *Amphibolite* (*Hornblende-schist.*)—This slide was cut from a specimen which was labelled by Tuomey as having come from West Point, Ga. It was found in the University collection at Tuscaloosa. It is a coarse grained schistose rock. The microscope shows no constituents but a very fresh compact common green hornblende in large prismatic crystals.

Conclusions.—In the preceding pages I have described a series of rocks consisting of sedimentary and igneous

rocks and also certain schistose crystalline rocks whose origin is unknown, and which are usually included under the general name crystalline schists.

Sedimentaries:

Spec. 9, Quartz schist.
" 14 " "

Eruptives:

Spec. 2, Biotite granite.
" 3, " " (gneissoid.)
" 4, " " "
" 5, Leucite tephrite.
" 6, Biotite granite.
" 8, Diabase.
" 10, 11, 12, 13, Biotite gneiss (metamorphosed granite.)
" 15, Diorite.
" 17, 18, 19, Hornblende Olivine Rock (Cortlandtite.)
" 21, Diorite.
" 22, Diorite.
" 23, Hornblende Olivine Rock (Cortlandtite.)
" 24, Diorite.
" 25, Diorite.
" 26 and 27, Alteration products of Diorite.
" 29, Augite Norite.
" 30, Hornblende Pyroxene Rock.
" 31, Serpentine.
" 33, Diorite.

Crystalline Schists.

Spec. 16, Amphibolite.
" 20, "
" 32, Biotite gneiss.
" 34, Amphibolite.

Of these the sedimentaries are comparatively unimportant, their relations not having been observed.

The igneous rocks are the most numerously represented,

and are by far the most interesting. Individually Sp. 18 is worthy of notice on account of the alteration of the green spinel, pleonaste, this being, as far as I can learn, the first rock in which such an alteration has been observed. In this connection attention may be called to the fact that the iron ore and emery segregation veins of the Cortlandt series,* which contain large amounts of pleonaste according to Williams,† occur in rocks related to this.

A spinel occurring with corundum in association with serpentine rocks has been reported from Dudleyville, Ala., a locality not very far distant from the point where the Cortlandtite is found. May not this be an occurrence similar to the iron ore, emery and spinel association from the "Cortlandt Series?"

Sp. 29, as an excellent type of augite norite, and Sp. 15, in which the micropegmatitic intergrowth of epidote and feldspar is to be seen, are also interesting. Sp. 10, 11, 12, 13 are remarkably fine examples of a dynamo-metamorphosed rock.

The general assemblage of eruptive rocks bears a striking resemblance to certain types described from the Cortlandt area of Westchester county, N. Y., and from Baltimore, Md., by Williams,‡ from Delaware by Chester,§ and from Ilchester, Md., by Hobbs‖.

They are also closely related to the peridotites de-

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*Dana, Am. J. Sci. XX, 1880, pp. 199-200.

†Norites of the "Cortlandt series." Am. J. Sci. 33, 1887, p. 194. Uber Pleonaste and Hercynite. N. Jahrb. II, 1887, p. 263.

‡Cortland Series. Am. Journ. Sci. iii, vol. 31, 1886, pp. 26-41; vol. 33, 1887, pp. 135-200: vol. 35, 1888, pp. 438-448.

§Gabbros and Associated Rocks in Delaware. Bull. 28, U. S. G. S., 1890.

‖Some Metamorphosed Eruptives in the Crystalline Rocks of Maryland. Trans. Wis. Acad. Sci., Arts & Letters, vol. 8, 1890, pp.

scribed from North Carolina by Julien,* Wadsworth,† and Williams,‡ and from Kentucky by Diller.§ The distribution of such rocks is thus shown from the extreme south-east extension of the Appalachian system in Alabama almost throughout its entire length. It is highly probable that further researches in the region from which the above specimens were gathered will disclose another such beautiful case of magmatic differentiation as was described from the Cortlandt series by Williams,‖ and of metamorphism of the gabbros and diorites as illustrated in the papers of Williams, Chester and Hobbs, above referred to.

I have left with the igneous rocks a few specimens, 4, 6, 7, 10, 11, 12 and 13, whose schistose condition alone would cause them to be placed in the succeeding category of crystalline schists, but which after microscopical study seemed to me to be of eruptive origin. It would perhaps have been well to have placed Sp. 15, 21, 22, 24, 25 and 33 under the crystalline schists as plagioclase amphibolites. They, however, bear such a striking resemblance to similar rocks, which after a careful and very detailed study of their field relations, have been proved to be diorites, that I have retained them among the eruptive rocks.

The crystalline schists include those which are markedly schistose and whose origin is entirely unknown. They were found associated with and cut by the igneous rocks. Future studies may show them to be metamorphosed phases of some of the eruptives.

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*Proc. Boston Soc. Nat. Hist., vol.

†Olivine Rocks of North Carolina. Science, vol. 3, No. 63, 1884, p. 486.

‡The Non-feldspathic Intrusive Rocks of Maryland and the Course of their Alteration. Am. Geol., vol. 6, 1890, p. 44.

§Peridotite from Elliot county, Ky. Am. Journ. Sci., iii, vol. 31. 1886, p. 121: Bull. U. S. G. S., No. 38, 1887.

‖l. c.

Taking the rocks as a whole, disregarding the quartz-schist, their general characters are those of that great mass of rocks which lies below all beds of undoubted sedimentary origin, and which are known as the Archaean rocks.

Supplementary Notes of Dr. Clements.

In the summer of 1894, I collected from the vicinity of Gold Hill, in Lee county, and from a railroad cut near Dadeville, specimens of eruptive rocks which were submitted to Dr. Clements for examination. His report is as follows:

"No. 1. (35) From near Gold Hill, Lee county. This is a very fresh specimen of a typical *Olivine-diabase*. Fine grained. The mineral constituents given in order of age are, apatite, triclinic feldspar (anorthite), olivine, magnetite, augite. Feldspar and augite predominate, then comes magnetite with very little olivine and apatite. The triclinic feldspar is *anorthite* and occurs in long lath-shaped individuals showing polysynthetic twinning. It is for the most part quite fresh. Beginning decomposition makes the plates appear somewhat dull. In a more advanced state these dull spots are seen to be made up of minute grains of epidote. The *augite* is in very light brownish grains and wedge-shaped pieces which lie between the feldspar individuals, as a cement, and from them have received their outlines. The characteristic cleavage angle is well marked. Augite is very fresh. *Magnetite* appears in irregular individuals with only one or two crystal faces developed, the rest of its contours being determined by the feldspar crystals touching it. *Olivine* is present in only one large crystal. It is partially altered, serpentine forming around the edges and along the cleavage lines. A few obscure greenish spots in the ground mass may be completely altered olivines. *Apatite* is scarce, occurring in long needles penetrating the other minerals. The structure of the rock is typical ophitic.

No 2 (36). From railroad cut near Dadeville. *Hy-*

persthene-gabbro with a great deal of hornblende and biotite; might be called a *hypersthene-hornblende-biotite gabbro.* Coarse grained, granitic structure.

Hypersthene, the most characteristic mineral, occurs in rounded crystals surrounded by a border of compact green hornblende. Between the hypersthene and hornblende there is frequently a zone which is made up of the hornblende intergrown with a white mineral of very low angle and double refraction, probably feldspar. Hypersthene is pleochroic, from pink to light greenish tinge. The characteristic brown inclusions are present. It is very fresh, only in places along cleavage lines are there traces of beginning decomposition. *Diallage* is present in comparatively small quantity and is surrounded by the strong pleochroic green hornblende just as the hypersthene is. *Hornblende* occurs in a few large plates in the section, but for the most part as a border, varying very much in width around the pyroxene crystals. It is very pleochroic, the color changing from light yellow to bluish green and dark olive green. It contains numbers of dark interpositions, different from those in the hypersthene, in the form of rounded plates and long needles. Some of the apparent needles are undoubtedly only the plates on edge. For the most part they are perfectly opaque, but some permit a little light to pass through and are of a dark chocolate brown. The characteristic hornblende cleavage is frequently seen. It includes plates of biotite and large crystals of apatite and magnetite. *Biotite* appears in plates with its customary strong pleochroism, straw yellow to chocolate brown, and perfect cleavage. It is included both in the pyroxene and hornblende. *Feldspar* forms the mass of the rock and appears in polysynthetically twinned grains. It is the basic *anorthite*, and is perfectly fresh and clear. *Magnetite* is in rounded grains and is included in the

other minerals. *Apatite* occurs quite abundantly and in large crystals which have more or less rounded outlines. Feldspar, hypersthene and hornblende make up the mass of the rock, then diallage, biotite, magnetite and apatite. The structure is granitic, and the specimen is remarkably fresh.

No. 3 (37). *Hypersthene-hornblende-biotite-gabbro.*—Same locality as the preceding. What is said of No. 2 holds good for No. 3, except that the latter contains rather more diallage in proportion to the other constituents and also more biotite and apatite. In a few places the feldspars show signs of deformation in bent twinning lamellæ. This is, however, apparently only local, as it is seen only where decomposition has begun, and may be due to the hydration of the feldspar exerting pressure on the surrounding crystals."

In the following notes by Dr. Clements, Nos. 38, 39, 40 and 42, descrie the chief varieties of the green schists of the Hillabee type. Nos. 41 and 43 are probably altered sedimentary rocks; the latter is of some interest for the reason that in it through Clay county and parts of Coosa many years ago great numbers of pits have been sunk in the search for copper. The graphite seems to have been the attraction, and the prime cause of the search. I am not aware that copper has been anywhere found in it. No. 41 is a sample of the graphitic schist which extend through Coosa county parallel with the course of Hatchet creek and at no great distance therefrom:

(38) 1. Actinolite-epidote-schist. From McGhee's, Clay Co.

This a very fine grained compact grayish green schist, composed of epidote, in grains, lying in a fine felt of actinolite needles, with here and there a lenticular area of quartz. Nothing in it gives an indication of the origin of the rock.

(39) 2. Sericite-schist. From McGhee's, Clay Co.

This is macroscopically a light dirty yellow, schistose rock, with silky luster upon the faces parallel to the schistosity, and showing on traverse fracture a well marked "augen" structure on a small scale, a dark mineral forming the center of the eyes. Under the microscope the rock is seen to be composed of thin alternating bands of two kinds, one of which is composed essentially of cataclastic quartz, with a small amount of unstriated feldspar, the other of sericite, scattered actinolite needles, and a large quantity of small epidote grains. These sericitic bands show a very noticeable wavy structure, and extend across the thin section in undulatory lines, separating here and there to wrap around the hornblende which forms the eyes. Upon examination these eyes are seen to be made up of a number of fragments of a very dark green hornblende. The fragments in most, if not all, cases belong together, showing from the manner in which they are separated the crushing which the rock has suffered. The hornblende is compact in the center and cloudy with minute dark specks, but on the edges it is light colored, frayed out as it were, and passes over into aggregates of actinolite and epodite lying in quartz cement. As we go away from these eyes the quartz diminishes in quantity, and the actinolite also. Sericite begins to increase, and we pass over into the bands consisting of sericite and epidote, with a few needles of actinolite, and so dense that the quartz can not be distinguished. The quartz bands have scat-

tered actinolite needles and epidote grains in them here and there, and also a few flakes of sericite. The crushed character of the hornblende and quartz is sufficient evidence of the dynamo-metamorphic action to which the rock has been exposed, but no satisfactory proof of its original condition could be found. My belief is that it was not derived from a clastic, unless it was itself metamorphosed, but was derived from some eruptive rock.

(40) 3. Actinolite-epidote-zoisite-schist. Chandler's Spring.

This is a quite rotten, fine grained gray rock macroscopically. Besides the actinolite, epidote, and zoisite, it contains a small quantity of granular quartz, and is badly discolored by brownish iron hydroxide. It bears now no evidence of clastic origin, but it would really be impossible to say from what it was derived, whether from an eruptive or a sedimentary.

(41) 4. Graphite-schist. Ingraham's Mill. Clay Co.

This appears very much like the phyllites, exceedingly fine grained and fissile. It consists of a fine grained granular aggregate of quartz and feldspar, with rounded zircon crystals and fragments of tourmaline and flakes of sericite. The rock is rendered quite dark by innumerable minute needles of rutile and a black substance which is scattered all through it, occuring in specks without any determinable form. This substance has a black metallic luster in incident light, disappears when the rock is heated to a high temperature, and was determined to be graphite. Part of the rock is discolored by brown iron hydroxide derived from the alteration of ferruginous carbonate, which occurs in well developed rims in parts of the rock. If, like many others, you consider the presence of graphite as sufficient evidence of the existence of living organisms from which it was derived, then the original sedimentary character of the rock is proven, although now it is so metamorphosed

that it contains no indications (other than the presence of graphite) of its origin.

(42) 5. Actinolite-schist. Lecroix, (Millerville,) Clay county.

Fine grained green schist, seen under the microscope to be composed of actinolite, epidote, flakes of chloritic material, and sphene, in a clear granular groundmass of clear unstriated feldspar and some quartz. The granular aggregate is rendered schistose by the parallelism of the actinolite needles and chlorite flakes. It is impossible to determine the original character of the rock.

(43) 6. Graphitic muscovite-schist. J. W. House. Clay Co.

Macroscopically the rock is a medium grained grayish-blue schist, showing large light greenish clumps of muscovite. Under the microscope it is found to be composed of quartz, muscovite, and graphite, with spots of white opaque leucoxene-like substance. Cataclastic structure is very plainly shown by the quartz. If the graphite is here, as in No. 4, to be considered sufficient evidence of life, it is probable that the rock is of sedimentary origin, though it exhibits now no sedimentary character.

(44) 7. Mica-schist (shistose eruptive rock). Darsey No. 4. Coosa Co. A dark bluish-black fine grained more or less schistose rock. Under the microscope we find a few eyes of grayish and altered triclinic feldspar, which lie in a fine grained cataclastic groundmass composed of quartz and feldspar mosaic—in which the quartz predominates—with flakes of brown mica and some chlorite. There are also found large quantities of sericite, with a considerable quantity of fairly large crystals of epidote, and rare ones of reddish sphene. The mica and epidote are present in large quantities, and almost obscure the clear white elements of the groundmass. The rock is clearly at present in a very badly mashed condition, and was probably derived from

an acid, granitic eruptive.

(45) 8. Amphibolite or hornblende schist. Darsey No. 5. Coosa Co. Dark green schistose rock made up of strongly pleochroic, common green hornbledė in, small partly automorphic crystals, together with a large quantity of magnetite and considerable epidote, in a granular groundmass of unstriated feldspar, with some quartz. The hornblende is beginning to get fibrous along the cracks which traverse the crystal perpendicular to prismatic cleavage. The rock is now a crystalline schist, of which nothing more can be said than that it was probably derived from some such basic eruptive as probably a gabbro.

3. PRELIMINARY PETROGRAPHIC NOTES ON SOME METAMORPHIC ROCKS FROM EASTERN ALABAMA,

BY

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The following notes are the results of a brief examination of some twenty specimens which were submitted to me by Dr. Smith. No attempt has been made to go into minute mineralogical details, the determination of which will require further study. The naming of the rocks is only tentative, until further petrographic investigation and chemical analyses shall determine their true classification.

The metamorphic rocks of Alabama and Georgia may be differentiated into two series. The older, or crystalline series, includes crystalline schists and gneisses, whose origin is doubtful, together with large masses of gneissoid granite. The younger, or clastic series, is typically made up of phyllites, sericite schists, chlorite schists, conglomerates, usually containing much feldspar, quartzites, crystalline sandstones, and, in a portion of the region, limestones and marbles. In many cases this younger clastic series has been so metamorphosed that it is difficult to distinguish its members from the older crystalline complex. The rocks of both series are closely associated with rocks of undoubted igneous origin.

In some portions of the area there are broad belts in which the country rock is largely igneous. Such a zone of igneous rocks, which are chiefly basic, extends through the northern portion of Cobb County, through the central portion of Paulding into Carroll County, Georgia.* Another area of igneous rocks, which are also chiefly basic, has been mapped by Mr. Hayes in the southern portion of Cleburne County, Alabama.† The granites associated with the crystalline schists of the basal complex have already been mentioned.

The major portion of the igneous rocks of the two series are intrusive, but it is probable that further investigation will prove that some of the metamorphic schists of the region are altered effusive rocks.‡ Most of the igneous rocks seem to have been intruded previous to the deformation of the associated rocks, for, as a rule, they give evidence of having suffered extreme dynamic metamorphism.

CLASTIC ROCKS.

Among the twenty specimens submitted to me, only one rock (No. 2) showed any evidence of clastic origin.

No. 2. (101a and 101b) Locality: Blake Mountain, 3 to 4 miles south of Arbacoochee, Cleburne County, Alabama.

Siliceous-magnetite schist. Megascopically this is a fine-grained siliceous rock of dark blue color. It is irregularly banded by alternating layers of magnetite and vitreous quartz. Small crystals of garnet form "knot-

*Unpublished Tallapoosa and Cartersville folios.

†See also Geological Map of Alabama, published in 1884, where the area is also shown. E. A. S.

‡A microscopic examination of a specimen from Owl Creek, 2 miles south of Lovingood's Bridge, Cherokee County, Ga., shows it to be on acid effusive rock. Prof. Williams described a porphyry from the "Archæan Area of Georgia near Tennessee" in American Journal of Science. Vol. 7, No. 6, p. 57, July, 1893.

en" on the cleavage surface of the schist. A rough separation of the magnetite and quartz, gave about equal volumes of each.

A microscopic examination confirms the above, and proves that quartz and magnetite are the essential minerals of the rock. The quartz occurs as a fine mosaic of interlocking grains. Much of it is presumably of clastic origin. Some of the quartz has, what is apparently, an inner clastic grain, which has been enlarged by a secondary deposition of quartz, oriented in optical continuity with the original grain. Secondary quartz also occurs as interstitial deposits between the original grains. Magnetite occurs sparingly as octahedral crystals, but usually as irregular masses and very fine grains. Magnetite is in many cases included in the secondary quartz as fine grains. Some of the magnetite is surrounded by a zone of leucoxene, which suggests that it is probably titaniferous. No garnets were observed in the thin sections.

This rock is part of a metamorphic zone which has been mapped by Dr. C. Willard Hayes, U. S. Geological Survey, as crossing the southeast corner of the Anniston sheet near Micaville. *This zone consists of garnetiferous, siliceous, and kyanite schists, and is probably a part of the younger clastic series.† The metamorphism may be regional but the proximity of large intrusive masses of diorite rocks, suggests a local cause.

GNEISSES.

Under this heading I have grouped the rocks which

*I am indebted to Mr. Hayes, of the U. S. Geological Survey, for the use of his notes on the unpublished Anniston and Tallapoosa folios, and for much general information in regard to this region.

†The Geological Map of the State, published in 1894, shows with approximate accuracy, the position of this zone which is part of the Talladega slate series. E. A. S.

have no very close affinities but all show a gneissoid structure.

No. 1. (100a and 100b) Locality: Country rock from Arbacoochee, Cleburne County, Alabama. *Biotite-chlorite gneiss.* Megascopically, the hand specimen shows this to be a grey-green colored rock, having a rather indistinct foliation. The foliation is produced by seams of dark green minerals which are mostly chlorite and biotite. Quartz and feldspar occur in irregular masses, which are somewhat elongated, and roughly parallel.

The microscope discloses a rock made up of feldspar (plagioclase?) largely replaced by secondary minerals: quartz, much of which is secondary; biotite partly altered to chlorite; a few scattered grains of augite: epidote, and a little muscovite.

Where the outline of the feldspars can still be traced they appear as tabular idiomorphic crystals. Much of the feldspathic material is replaced by quartz, as mosaics of interlocking grains, or by epidote and zoisite. Faint traces of either lamellar twinning or Karlsbad twinning can usually be observed in the altered feldspar. Under crossed nicols the outline of the original feldspar is often entirely lost, for there is a gradual merging into the groundmass. In some cases a zone of clear fresh-looking feldspathic material surrounds the altered feldspar phenocryst. This outer rim, which must be a secondary enlargement, shows no twinning and is probably albite. The original rock seems to have contained plagioclase and orthoclase in about equal proportions.

Quartz occurs as irregular mosaic patches of interlocking grains, which are probably recrystallizations of the silica of single quartz individuals, or replacements of feldspars.

The groundmass consists of allotriomorphic grains of quartz interwoven by irregular stringers of biotite and

chlorite. Biotite and chlorite also occur in larger masses, which are always elongated and have a rough parallelism, thus giving the rock its foliated structure. Epidote occurs in the groundmass, and also as a secondary mineral after plagioclase, in small prisms. The zoisite, secondary after plagioclase, occurs as very fine grains and granular aggregates. This rock probably belongs with the gneisses of the basal complex, although the typical gneiss differs from this in having a granular instead of a porphyritic structure.

No. 14b. (114a and 114b) Locality: 1 mile north of West Point, Georgia, in Chambers County, Alabama.

Biotite-gneiss: Megascopically, this is a gray and white banded rock; the dark bands consisting of biotite and a ferro-magnesian silicate, and the light bands, of white feldspar and glassy quartz.

A microscopic examination shows the rock to consist essentially of quartz, biotite, feldspar, and hornblende. It has an orignal granular structure, with a secondary foliated structure.The segregation of the basic minerals into parallel zones gives it the banded appearance.

The quartz and feldspar occur in allotriomorphic grains, and individuals. Except some of the fine quartz grains, which are probably secondary, both quartz and feldspar are cataclastic. All of the feldspar shows polysynthotic twinning.

Biotite and green hornblende are present in about equal proportions and are closely associated. Biotite occurs in irregular shreds and plates, and the hornblende in deformed prismatic crystals. As an accessory constituent there are present a few grains of augite, and considerable brown tourmaline in small grains. A little chlorite is found in the rock as a secondary mineral after biotite.

The locality of this specimen is so isolated that a lithologic correlation can be of little valne. It bears a

close resemblance, however, to the specimens of gneiss which were collected from the basal complex of Cleburne County, Alabama, and Carroll, Cobb, and Cherokee Counties, Georgia. The rock in question (14b) differs from the other gneisses in respect to the predominating ferro-magnesian silicate. In this specimen from Chambers County (14b), hornblende is very plentiful, while augite is only an accessory mineral. In the other gneisses, from the region farther north, augite predominates very largely over hornblende.

Nos. 15 and 16. (115a, 115b, 116a, 116b.) Locality: Wright's Mill, near Auburn, Lee County, Alabama.

Augen Gneiss.—Megascopically the rock consists of a dark groundmass of mica, filled with augen of quartz and feldspar. The augen are either lenticular, or drawn out to thin seams. They vary from two inches to microscopic in diameter.

Microscopic examination shows that this rock contains quartz and feldspar, as minerals forming the augen, and biotite, chlorite, and epidote in the groundmass.

The quartz, where it is not completely granulated, gives wavy extinction, except in a few cases, in which it seems to be secondary. The feldspar is for the most part plagioclase, but a few large phenocrysts of orthoclase, showing Karlsbad twinning, were also observed. Structurally the augen are of two kinds. First, those formed of single mineral individuals; and second, those formed of an aggregation of minerals. The extreme mechanical deformation that this rock has undergone, is well shown by the granulations and alterations to which the augen have been subjected. In many cases the phenocrysts of feldspar or quartz, have been granulated on opposite sides, corresponding to the direction of the schistosity, and the material thus formed has been drawn out into a lenticular-shaped mass, with the solid portion of the

minerals as a nucleus. In other cases the original phenocryst has been entirely granulated, and the material thus formed has been drawn out into a lenticular-shaped mass, or sometimes even into a mere thread.

In many cases the augen are not phenocryst, but are probably parts of the original rock, which have been separated by the lines of shearing, now marked by the groundmass of biotite and chlorite. These composite augen have the same lenticular shape and granulated boundaries as the simple augen. The composite augen have a holocrystalline structure and are composed chiefly of plagioclase feldspar, with some orthoclase and quartz, and a little biotite and epidote. It is possible that they are not fragments of the original rock, but are the results of the recrystallization of the feldpathic material, of single phenocrysts.

The groundmass of the rock consists chiefly of biotite, which has been greatly squeezed, and bent to conform to the countour of the augen. A little chlorite is associated with the biotite. Grains of epidote are scattered throughout the groundmass. Small lenticular grains of quartz are also found in the groundmass.

As in the case of the last described specimen, the locality of this rock is too remote from that at which any other material was collected, to make a lithologic comparison of any interest. Before its mechanical deformation it seems to have been a basic or intermediate porphyritic rock. The present dark silicates of the rock are probably all secondary, and afford little information as to its original mineralogical composition.*

IGNEOUS ROCKS.

The rocks of the metamorphic area of Alabama, and

*See also Dr. Clements' description of the same rock. E. A. S.

the adjacent portions of Georgia, have been exposed to the disintegrating atmospheric agencies during two periods of base leveling, and are therefore deeply weathered. The petrographical investigation of these rocks is attended with difficulties, for it is seldom that specimens can be secured from below this zone of weathering.

Nearly all the rocks examined by me from this region, contained an abnormally high percentage of quartz. In many cases a part of the quartz is plainly secondary, being deposited subsequent to the deformation of the rock; while in other cases, the existence of two generations of quartz seemed probable, though positive evidence was wanting. The source of the silica of the secondary quartz can usually be traced to the breaking down of the silicates of the feldspars, but in some instances it seems to have been derived from infiltrating solutions. In the basic rocks, secondary quartz is frequently accompanied by calcite. The kaolinization of the feldspars and chloritization of the dark silicates are among the most frequent observed phenomena, accompanying the weathering of these rocks.

Besides these superficial alterations, many of the igneous rocks of the region have been subjected to the metasomatic and paramorphic changes which accompanied the mechanical deformation of the province. A rock which has suffered these various phases of metamorphism is frequently entirely altered, both as to chemical composition, and physical structure. The determination and classification of the igneous rocks of the region, is therefore, a difficult problem.

ACID ROCKS.

Granite is the prevailing type of acid rock, and in fact the only one which has thus far been definitely deter-

mined. Some rocks which have been classed as granites may prove to be syenites, their quartz being secondary. There are also, in the region, some aplite dikes which are apophyses from larger granite masses.

The granites have two distinct phases, between which, however, there are intermediate types.

The more acid granite is made up of quartz, orthoclase, microcline, muscovite, and biotite, with very little lime soda feldspar, together with accessory minerals. The more basic type is an aggregate of quartz, orthoclase, microcline, with considerable plagioclase, and biotite, hornblende, together with accessory minerals.*

Of the twenty specimens sent by Dr. Smith, fifteen were classed as igneous or altered igneous rocks, and of these only one is an acid rock.

No. 17. (117a and 117b). Locality: 3 miles west of Loachapoka, Lee County, Alabama.

Granite.—This rock shows a typical granite structure. Pink feldspar, glassy quartz, and biotite can be distinguished megascopically.

Microscopically, the rock has granular structure and the mineral constituents are all allotriomorphic. The feldspars are chiefly potash-feldspars, both orthoclase and and microcline being present. The orthoclase shows no twinning, while the microcline shows the double twinning, giving the characteristic cross hatched structure. A multiple twinning feldspar which is present in limited quantities is probably albite. The feldspars when not too much decomposed show more or less cataclastic structure.

The quartz of the granite, which occurs in irregular masses, is much fractured and gives wavy extinctions.

*The rock from Stone Mountain, Georgia, is an example of this granite. The occurrence described by C. W. Purington, in The American Geologist, Vol. XIV, p. 105. August, 1894.

Biotite is uniformly distributed through the rock, as small scales and plates. Magnetite occurs sparingly as accessory mineral. Muscovite and kaolin are present as decomposition products of the feldspars.

This granite belongs to the more acid type described above. Mineralogically this granite is quite similar to one collected by Mr. Hayes near Mount Zion, Carroll County, Georgia. The Mt. Zion granite has, however, been subjected to mechanical deformation, which has given it a secondary parallel structure.

BASIC ROCKS.

The greater part of the basic rocks of the region can be embraced under the field terms, "greenstones," and "greenstone schists." These rocks are even more liable to alteration by atmospheric agencies than the acid rocks, and are correspondingly difficult to determine. In the collections made by Mr. Hayes and myself, there are examples of diorites, gabbros, diabases, pyroxenites, together with many hornblende, chlorite, and epidote schists whose antecedents are more or less doubtful. This collection includes no olivine bearing rocks, but Dr. Smith* has described an olivine rock from near Notasulga, Alabama.†

The talc (soapstone) slates which are not uncommon in this metamorphic area, are probably alteration products of very basic rocks, but as far as I know they have

*Outline of the Geology of Alabama.

†This is the Ossipyte described by Prof. Hawes, No. 22 of his list. Other olivine-bearing rocks see the notes of Dr. Clements on specimens No. 17, 18, 19, and 23, and also on the specimen from near Gold Hill, in Lee county, No. 35. E. A. S.

received no petrographical study. The rocks associated with the corundum deposits are also of very basic nature.*

The basic rocks of Alabama have been described by Dr. Smith and his assistants as hornblendic gneiss, hornblende schist, diorite, talcose slate, steatite and chloritic schists, in the various publications of the Survey. In

*See Bulletina 1 and 2, Geological Survey of Georgia.

Georgia* McCallie and King have classed the basic rocks as hornblende gneisses, hornblende rocks, periodotites, etc.

Like the acid rocks, the basic rocks are characterized by a high percentage of quartz, most of which is plainly secondary. In at least one instance an isotropic substance was observed which resembled opal.† The other secondary minerals observed are calcite often present in large quantities, hornblende and uralite, albite (?) (No. 5), epidote, zoisite, chlorite, leucoxene, garnet, and spene. Two examples of saussurite gabbro have been recognized‡.

It is evident that the above list includes both the secondary minerals which are the result of dynamic metamorphism, and those which owe their existence to atmospheric action, or weathering.

Regarding the occurrence of the basic rocks, as far as our present knowledge goes, they are all intrusive. They occur as dikes, and larger intrusive masses, in both the older and younger series. the larger masses, however, seem to be confined to the basal crystalline series. As these basic rocks show wide differences in their relative amount of metamorphism, it is probable that there was more than one period of intrusion. As

*Preliminary Report on the Corundum Deposits of Georgia, by Francis P. King, Geological Survey of Georgia, Bulletin No. 2, pages 71-4, 80.

†No. D 6. Chestnut Gap P. O.. Gilmer Co., Ga.

‡Nos. D 7 and D 11, from near Allatoona, Bartow Co., Ga.

yet the relative ages of the different types of basic rocks, have not been determined. In general the basic rocks occur in broad belts which have considerable extension along the strike. Such a belt has been mapped by Mr. Hayes and his assistants extending through Cobb, Paulding, into Carroll counties, Georgia, and judging from specimens sent me by Dr. Smith, it extends into Randolph county, Alabama.

Until more material has been collected, with the end in view of tracing one phase of a rock into another (for example from massive to schistose) the classification of these basic rocks must be more or less arbitrary. For convenience of description I have divided them into schistose and massive rocks. The term schist is used in a relative sense only, for as a matter of fact nearly all these basic rocks have a more or less well marked cleavage.

Diorites.

Diorites are the most common basic rocks of this region. They occur as dikes in the younger series, and as dikes and larger intrusive masses in the basal crystalline series. There are two main types:* The quartz diorites in which quartz is a prominent mineral, and the ordinary diorites, in which it plays only a secondary part. We are here again confronted with the difficulty of determining which is primary, and which is secondary quartz, but it seems probable that the quartz diorite type predominates in the region. Dr. Smith sent me one each of these two types.

It should be noted that in these altered rocks it is not always possible to determine whether a rock should be classed as a diorite, or as an epidiorite. The alteration of augite to compact hornblende and uralite is a common

*It should be noted that no chemical analyses have been made of these rocks, and the percentage of silica may prove to be so high that they can not be classified as basic rocks.

paramorphic change, and with limited amount of material, it is often not feasible to determine whether the amphibole be primary or secondary. As a temporary expedient, therefore, I have classified the rocks showing little or no ophitic structure, and in which the feldspar is an acid labradorite, as diorites, unless the amphibole is plainly secondary after augite. The rocks which had a marked ophitic structure, and whose feldspar was the more basic labradorite, I have classed as diabases, or epidiorites as the case may be.

No. 14a. (113a and 113b) Locality seven or eight miles north of Columbus, Georgia, in Lee county, Alabama.

Diorite.—Megascopically a green and white speckled, medium grained rock, in which hornblende, feldspar and quartz can be distinguished.

Microscopic examination shows this to be an even grained holocrystalline rock, whose original structure has been more or less defaced by a secondary parallel structure. It is made up of green hornblende, plagioclase, quartz, a little augite, and epidote and calcite, as secondary products. Some of the plagioclase occurs in tabular crystals, and these together with the hornblende suggest an ophitic structure.

The plagioclase is well twinned and the lamellae give a maximum extinction of about 30 deg., indicating labradorite. The augite is associated with hornblende. The quartz occurs in small, clear, lenticular grains. A few irregular patches of epidote and calcite were observed in the slide.

No. 18. (118a, 118b and 118c) Locality, Ragan's Old Mill, Lee county, Alabama.

Quartz-diorite.—This is a dark green, schistose rock, in which hornblende and feldspar can be distinguished megascopically.

Microscopically the chief constituents are seen to be green hornblende, plagioclase and quartz. The rock is holo-crystalline, and has a secondary parallel structure. Hornblende is the predominating mineral and it occurs in elongated allotriomorphic masses. The feldspar is the oldest constituent and it has a tendency to assume lath-shaped crystals. It is well twinned and the lamellae extinguish at about 30 deg. as a maximum, indicating a labradorite. The twinning according to albite law is frequently accompanied by both Karlsbad and pericline twinning.

Quartz occurs in irregular patches, much fractured and giving wavy extinction, and is probably a primary constituent of the rock. It is also present in larger masses, showing no cataclastic structures, and this is evidently a secondary constituent of the rock.

Hornblende Schists.

This embraces a series of schistose rocks, consisting chiefly of quartz and hornblende, with often some plagioclase, and usually some augite. They are probably alteration phases of diorites and quartz diorites.

No. 7. (106a and 106b) McDiarmid Old Place, near Brownsville, Clay county, Alabama.

Hornblende-schist.—Megascopically this rock is of dark green color. Crystals of green hornblende occur in an aphanitic ground mass.

Microscopic examination shows that the essential minerals of this rock are green hornblende, quartz, muscovite, and epidote. The hornblende occurs in irregularly bounded masses, scattered through a groundmass, consisting of quartz, muscovite and epidote.

The groundmass consists of lenticular quartz grains interwoven by shreds of muscovite. Epidote occurs as scattered grains and granular masses. Calcite occurs

sparingly in small masses. It is interesting to note the presence of muscovite which was not observed in any other of these schists.

No. 10 (109a and 109b). Locality, two miles west of Idaho, Clay county, Ala.

Hornblende-schist.—Megascopically, this is a fine grained dark green rock. Prismatic crystals of hornblende can be distinguished, and smaller grains of quartz and feldspar.

Microscopic. A rock made up of pale green hornblende, augite, plagioclase and quartz. The hornblende occurs in elongated masses arranged parallel. Augite is associated with the hornblende. Plagioclase is not very plentiful, and occurs as tabular crystals. The feldspar shows multiple twinning, but the determination of it is unsatisfactory. Epidote is scattered through the rock in small grains. Quartz occurs in lenticular grains and seems to be entirely secondary.

No. 19 (119a and 119b). Locality, one mile south of Double Bridges Ferry, Elmore county, Ala.

Hornblende-schist.—Megascopically, this rock is of a dark green color, and has almost a slaty cleavage. When broken across the cleavage it is seen to be a finely banded crystalline schist. Dark bands of prismatic crystals of hornblende and chlorite alternate with light bands, composed chiefly of fine grains of quartz.

Microscopic. The thin section discloses green hornblende quartz and a little augite to be present. The hornblende occurs in prismatic crystals which have a rough parallelism and are partially altered to chlorite. The quartz occurs as irregular, interlocking grains. A few grains of augite were observed scattered through the section. Considerable magnetite is present in irregular shaped masses, and octahedral crystals.

Diabases.

Under this heading I have grouped diabases, quartz diabase, epidorite, and some schists which are plainly mechanically deformed phases of these rocks. The quartz diabase seems to predominate in the region, but we are here again involved in the difficulty of distinguishing between the primary and secondary quartz.

No. 13. (112a and 112b) Locality, two miles southeast of Fredonia, Chambers county, Ala.

Epidiorite.—Megascopically, this is a medium coarse grained rock, made up of dark green hornblende, white feldspar and quartz.

Examination of thin section shows the rock to be made up of hornblende, augite, plagioclase, quartz and epidote. The minerals are all arranged more or less parallel, and the original structure of the rock has been defaced. Except the plagioclase, which shows a tendency to crystallize in tabular form, the minerals are all allotriomorphic.

The hornblende is of a pale green color, and is plainly derived from the augite. The transition from augite to hornblende can be observed in the thin section.

The plagioclase, which is not very plentiful, shows albite twinning, but the determination is unsatisfactory. Quartz occurs as an alteration product in small irregular grains.

Epidote is the most plentiful mineral. It seems to be an alteration product of both the feldspar and the ferromagnesian silicates.

No. 11. (110a and 110b) Locality, near Louina, Randolph county, Ala.

Diabase-schist.—Megascopically a finely banded rock. Dark bands of green hornblende alternate with light colored bands of pink feldspar.

Microscopic examination shows this rock to be made up of pale green hornblende, plagioclase, with a little quartz and augite. The original structure of the rock has been entirely destroyed by the mechanical deformation. The hornblende occurs in irregular elongated masses, having a rough parallelism. The augite is closely associated with hornblende.

The plagioclase occurs in patches of mosaic intergrowths, which are probably formed by secondary recrystallization of the feldspar. With it is associated a little quartz. The albite twinning is rather inconspicuous, and the determination of the feldspar unsatisfactory, but it probably belongs near the basic end of the lime-soda-feldspar series. Epidote is scattered through the rock in small grains.

No. 12. (111a and 111b) Locality, one and one-fourth miles north of Fredonia, Chambers county, Alabama.

Quartz-diabase.—Megascopically this is a dark green holocrystalline rock. Dark green hornblende, white feldspar and glassy quartz can be distinguished in hand specimens.

A microscopic examination reveals a rock with partially defaced ophitic structure, consisting of hornblende, plagioclase and quartz. The rock has a parallel structure induced by the mechanical deformation. The plagioclase exhibits a tendency to form tabular crystals. The lamellæ give a maximum extinction of about 40 degrees, indicating a basic labradorite. The hornblende occurs in irregular allotriomorphic masses, which often enclose the feldspar crystals. The hornblende is dark green, and shows an extinction of about 20 deg. The hornblende is partly altered to chlorite. Quartz occurs in irregular grains, which, like the feldspar, are cataclastic. Small grains of epidote are scattered through the rock.

No. 3. (102a) Locality, Oakfuskee, Riddle's Bridge, Alabama.

Quartz-diabase-schist.—Microscopic.* Int hin section of this is seen to be a holocrystalline rock, in which a secondary foliation has been produced by mechanical deformation. It consists essentially of pale green hornblende (partially altered to chlorite), plagioclase, quartz, which is probably mostly secondary, with a little augite and zoisite.

The feldspar, which is probably anorthite, occurs in broken and partially replaced crystals, which were originally tabular. The hornblende occurs in irregular masses elongated parallel to the foliation. The original structure of rock was evidently ophitic.

Quartz occurs in small irregular patches all through the slide, often replacing in part the plagioclase crystals. Much of the quartz is fissured and gives wavy extinction. If this cataclastic quartz is secondary, it must have been formed previous to the mechanical deformation of the rock. The zoisite occurs as granules and prisms all through the rock. Epidote occurs sparingly in slide as small granular masses and scattered grains.

Pyroxenites.

The two rocks under this heading are characterized by the entire absence of feldspar and quartz. One of them is plainly a partly altered and squeezed pyroxenite. The other, which I have called an amphibolite, is made up chiefly of uralite, which is probably paramorphic after augite.

No. 9. (108a and 108b) Locality, Sec. 1, T. 24, R. 20 E., near Goodwater, Coosa county, Ala.

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*Hand specimen of this rock was lost.

Pyroxene-epidote-schist.—Megascopically, this is a pale green rock, on the fresh fracture of which the glittering surfaces of crystal faces can be seen. These crystals are of a light green color, and are contained in similarly colored groundmass.

Under the microscope the rock is seen to consist of pyroxene partly altered to epidote. In the slide no definite crystalline outline can, as a rule, be made out, but it seems to have originally been an intergrowth of prismatic crystals.

No. 8. (107a and 107b) Locality, D. C. Carmichael, near Brownsville, Clay county, Ala.

Amphibolite.—Megascopically, the rock is of light green color, and much resembles the chlorite schists previously described. The examination of thin section shows it to consist essentially of a holocrystalline intergrowth of a pale green hornblende. A little augite occurs with hornblende. Some of ths hornblende has been altered to chlorite. Quartz and feldspar are entirely wanting in this rock.

Chlorite and Epidote Schists.

This group includes all the most highly altered basic rocks of the region. Megascopically they are soft greenish rocks which often have a slaty cleavage, and can easily be mistaken for clastics. The microscopic study of a series of specimens of the schists show them to be of undoubted igneous nature. They are usually found to contain some secondary quartz, and often contain remnants of a feldspathic constituent. They are probably derived from the diorites and diabases, and from the most basic rocks.

No. 4. (103a and 103b) Locality, three-fourths miles southwest of Chandler Springs, Talladega county, Alabama.

Chlorite schist.—Megascopically, this is an aphanitic rock, having a light green color and an imperfect cleavage.

Microscopic. In thin section the microscope discloses a rock made up of hornblende, chlorite and zoisite. The chlorite occurs as plates with irregular outline, and as fibrous masses. The zoisite occurs as granules and prisms. A few grains of quartz were observed in section. The hornblende is pale green, and occurs in small fibrous masses.

No. 5. (104a and 104b) Locality, one mile south of Coleta, Clay county, Alabama.

Chlorite-epidote-schist.—Megascopically, the rock is of a light green color. Rounded phenocrysts of quartz and feldspar (chiefly quartz) are seen enclosed in a groundmass of light green color.

The microscopic examination shows it to be a highly metamorphosed rock, made up almost entirely of secondary minerals. It consists essentially of quartz, epidote, chlorite and zoisite.

Tabular crystals of what were once phenocrysts of feldspar are scattered through the rock. In several of these phenocrysts a little of the polysynthetic twinning feldspar was observed, but for the most part the feldspars have been entirely replaced by mosaics of interlocking quartz grains, or by aggregations of quartz, epidote and zoisite.

The groundmass of the rock consists of an aggregation of epidote, chlorite, zoisite and quartz. The chlorite occurs in irregular stringers, and the epidote usually intergrown with zoisite. Less frequently epidote occurs as separate masses and filling cleavage cracks. The epidote and zoisite seems to be secondary after augite, for a few unaltered augite grains were included in these aggregations of secondary minerals.

The quartz occurs as mosaics with irregular boundaries, and as small veins, cutting all the other minerals. There seems to have been an infiltration of quartz after the foliation of the rock. This would make two generations of quartz. First, that formed during the metamorphism of the rock, and second, that of secondary infiltrations after the foliation of the rock. There is also the possibility that the rock contained some primary quartz. The plagioclase feldspar noted above is probably the only primary constituent which the rock now contains. The rock is probably an altered diabase, which has been subjected to extreme metamorphism.

No. 6. (105a and 105b) Locality, Brownsville, Clay county, Ala.

Chlorite-epidote-schist.—Megascopically, this rock is of a light green color and of fine texture. The mass of the rock is made up of soft green mineral. Small flakes of muscovite are scattered through it.

Microscopic examination shows it to be a fine grained, foliated rock, consisting essentially of quartz, chlorite and epidote. Quartz occurs in lenticular grains which have a wavy extinction. Chlorite occurs in fibrous aggregates, arranged more or less parallelly, giving the rock imperfect cleavage.

Epidote is intimately associated with chlorite as grains and granular masses. Several irregular shaped masses of calcite were observed, and also a little zoisite associated with epidote. The rock also contains considerable muscovite in small plates.

It is interesting to note that section No. 105a contained one irregular mass of magnetite, for there is striking absence of that mineral in most of these rocks.

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GEOLOGICAL SURVEY

OF

ALABAMA,

EUGENE ALLEN SMITH, Ph. D., State Geologist.

BULLETIN No. 6.

PRELIMINARY REPORT

ON THE

CLAYS OF ALABAMA,

BY

HEINRICH RIES, Ph. D.

THE VANCE PRINTING CO., STATE PRINTERS AND BINDERS,
JACKSONVILLE, FLA.
1900.

To His Excellency,

JOSEPH F. JOHNSTON,

Governor of Alabama.

DEAR SIR:—I have the honor to submit herewith, as part of my biennial report, 1898-9, a report upon the clays of Alabama by Dr. Heinrich Ries. While the investigations of Dr. Ries here recorded have been confined to the northern half of the State, and mainly to one or two formations, they yet embrace the most important and most accessible of our clay deposits. The kaolins of the granite region lie at a distance from railroad lines, and the discussion of these and of the clays of the more recent formations, in the lower half of the State, will be taken up in a second bulletin.

The present report shows that our clay resources include every variety, ranging from the best of china clays downward, and there seems to be no good reason why all these materials should not be turned into the manufactured products, chinaware, stoneware, fire brick, ornamental brick, paving brick, tiles, drain pipes, etc., within our own borders and upon our own ground.

Very Respectfully,

EUGENE A. SMITH.

University of Alabama,

March 15, 1900.

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PREFACE.

Clay is one of the most abundant materials found in the earth's crust, and occurring as it does in every country, in almost every geological formation from nearly the oldest to the youngest, and frequently in positions easy of access, it is not to be wondered at that these conditions, aided by the peculiar properties which it possesses, have caused this material to become one of the most useful and valuable products of the earth.

The value of clay is still more readily understood when the statistics of its production are known. Thus in 1897, the total value of clay products made in the United States alone was $60,911,641.00, distributed as follows:

Common brick	$ 26,353,904
Pressed brick	3,931,336
Vitrified paving brick	3,582,037
Ornamental brick	685,048
Fire brick	4,094,704
Drain tile	2,623,305
Sewer pipe	4,069,534
Terra cotta	1,701,422
Fire proofing	1,979,259
Tile other than drain	1,026,398
Miscellaneous	1,413,835
Pottery	9,450,859

Up to the present time the rank of Alabama as a clay producing state has not been very high, owing largely to the lack of information concerning its clay resources, and in the following report an endeavor has been made to furnish as much information as possible concerning the characters of many of the Alabama clays.

HEINRICH RIES.

March 1, 1900.

I

GENERAL DISCUSSION OF CLAYS,

BY HEINRICH RIES.

ORIGIN OF CLAY.

Clay is to be met almost every where, and while it varies in form, color and other physicial properties, nevertheless it always forms a pasty or plastic mass when mixed with water, by virtue of which it may be molded into any shape, which it retains when dried; furthermore when exposed to a high temperature it hardens to a rock like mass. These two properties, the plasticity and the hardening when burnt are what make clay of such inestimable value to man.

Pure clay or kaolin is composed entirely of the mineral kaolinite, which is a hydrated silicate of alumina. It rarely happens, however, that clay is perfectly pure, for owing to the nature of its formation from another rock as will be explained later, it is very apt to have other minerals mixed in with it. These foreign minerals may sometimes be present in such quantities as to completely mask the character of the kaolinite.

We can therefore define clay as a mixture of kaolinite with more or less quartz and other mineral fragments, especially feldspar and mica, the whole possessing plasticity when mixed with water, and becoming hard when burned.

The so called flint clays form an exception to the above, for while they often approach pure kaolin in composition, still they are almost devoid of plasticity when ground and mixed with water.

Kaolinite is a secondary mineral resulting from the decomposition of feldspar. The feldspars are a group of silicate minerals of rather complex composition,

with orthoclase, the potash feldspar, serving as the type of the group, as well as being the commonest species.

Under the influence of chemical action. which may be the result of weathering or in some cases probably of acid vapors ascendning from the interior of the earth, the feldspar becomes decomposed, and the result of this is that the potash of the feldspar is removed partly in the form of solube carbonate, or perhaps silicate, or even fluoride, while the alumina and silica remain and unite with water to form the hydrated silicate of alumina, kaolinite, whose composition is expressed by the formula $Al_2 \; O_3, \; 2SIO_2, \; 2H_2O.$, or in the proportion of silica, 47.30 per cent.; alumina, 39.80 per cent.; water 13.90 per cent.

The change can be illustrated still better by the following in which the first column indicates the composition of the feldspar, the second the amount of water taken up in the process of decomposition, the third, the amount of matter removed in solution, and the fourth the relative amounts of the three ingredients of kaolinite.

	Feldspar.	Added.	Dissolved out.	Kaolinite.
Alumina....	18.3	....	0.0	18.3
Silica....	64.8	....	41.8	23.0
Potash....	16.9	....	16.9	....
Water.....	....	6.4	....	6.4

Many clays approach quite closely to kaolinite in their composition, and in some the percentage of alumina even exceeds the theoretic amount, by one or two per cent., and is evidently not due to errors of analysis.

It has been suggested by some that this may be due to the presence of a certain amount of *pholerite,* the amorphous variety of kaolin,* and while this is possible the same composition might be shown by a certain amount of bauxite or alumina hydrate mixed in with the clay.

* Wheeler, Clays of Missouri, Missouri Geological Survey, XI.

None of the Alabama clays thus far analyzed indicate this exceptional composition.

Knowing the mode of origin of kaolinite it will at once be seen that the purity of the kaolin depends on the nature of the parent rock. Feldspar often forms large veins of considerable purity, and nearly free from other associated minerals, and its decomposition in such cases would give rise to deposits of pure or nearly pure kaolin. In point of fact the purest clays known have with few exceptions been formed in this manner. More frequently quartz and mica are common accessory minerals, and remain intermixed with the kaolinite, both of them being more resistent to weathering than the feldspar. When these or other minerals occur in the kaolin they have to be separated from it as much as possible by washing.

Clays, which occur at or close to the locality in which they have been formed, are called "residual clays". They represent some of the purest types of clay known as well as the most impure. The upland region of the Southern States is underlain by a great area of feldspathic, granitic and gneissic rocks which have decomposed to a ferruginous clay of residual nature, and one that is used extensively in the South for the manufacture of common brick.

In the general wearing down of the land surface which is continually taking place the particles of residual clay are washed down into the lakes and oceans and deposited there as sediments, thus giving rise to what are known as sedimentary clays. They are usually far more plastic than the residual clays, especially the purer ones.

From the nature of their formation, we should seldom look for kaolins of sedimentary origin, and when they do occur they have probably been derived from large areas of very feldspathic rock or possibly from limestones which had an appreciable percentage of silicate of alumina in their composition, in which case the lime carborate would be carried off in solution, and the clay components of the rock be left behind as an insoluble residue. It is seldom that sedimentary

clays exhibit such remarkale purity as those from Chalk Bluff, Alabama, or the plastic ball clays of Florida.

The clays of the Cretaceous and Tertiary formations, which underlie the Coastal Plain, as well as the Palaeozoic shales found in Alabama, are all of sedimentary origin.

GEOLOGICAL STRUCTURE AND DISTRIBUTION OF CLAY DEPOSITS.

RESIDUAL CLAYS.

The mode of origin of these has already been explained. They may occur either in the form of a broad mantle overlying the bed rock and showing a variable thickness as well as extent, or they may occupy the position of a vein cutting across the strike of the other rocks, or extending at times with the bedding or lamination of them.

Residual clays are commonly made up of a mixture of angular grains which are chiefly undecomposed mineral matter, and clay particles which are mostly of sufficient fineness to remain suspended in water for an almost indefinite period. There is also generally a gradual transition from the fully formed clay at the surface to the fresh rock below, whose decomposition has given rise to the plastic mass above.

The depth below the surface at which the unaltered rock is encountered may be as little as three to four feet, while in some regions where the surface has been little eroded, and decomposition has been active, the thickness of the residual clay may exceed one hundred feet.

The structure of the parent rock such as stratification or lamination is at times often noticeable in the lower portion of the residual deposits, and in some cases it may even be preserved right up to the surface.

Residual deposits of the vein type result commonly from the decomposition of veins of granite or feldspar. They vary in width, from a few inches to several hun-

dred feet, and their vertical extent depends in most cases on the depth to which the weathering action has progressed.

Veins of kaolin seldom show great length, and when followed along the surface not uncommonly pinch out in both directions. They are often separated more or less sharply from the country rock, and this distinct line of demarkation is preserved even when the wall rock itself is decomposed. They furthermore frequently branch and at times contain lenses of quartz, which resist the weathering agencies and stand out in bold relief on the surface. It rarely pays to work a vein under six feet in width.

Deposits of kaolin of the type just described should not be confused with sedimentary deposits of white clay, which are usually of a much greater extent than the vein formation.

SEDIMENTARY CLAYS.

These occur in the form of beds, which are either close to the surface or interstratified with other deposits which have been accumulated in water, such as sandstone or limestone. They are not unfrequently interbedded with coal deposits and many a coal seam has a fire clay floor. Sedimentary clays are, as a rule more homeogeneous than residual ones, and contain probably a greater portion of fine particles. They are also more plastic, and frequently contain much disseminated organic matter. Furthermore, they do not pass gradually into the underlying rock as residual clays do, and indeed bear no relation, in a genetic sense, to the rocks upon which they rest.

When sedimentary clays become compressed by the weight of overlying sediments, they assume the character of hard or consolidated rock, and are known as shale. Shales therefore simply represent the finest clay sediment which has bcome consolidated.

On grinding to a powder and mixing with water, shales become just as plastic as other clays. By mentamorphism, (that is heat and pressure developed

by mountain making processes) taking place in the crust of the earth, a shale may lose its chemically combined water, develop a cleavage, and become converted into slate. It is then no longer possible to develop any plasticity in the material.

It is not to be understood that all sedimentary clays are of a homogeneous structure throughout. Some beds may exhibit a wonderful similarity of composition throughout extended areas, while again there may be a wide variation in the character of any bed within narrow limits. Apart from this variation laterally, there may also be a vertical one in cases where the deposit is made up of a number of beds, one over the other, each showing distinctive characters. With such occurrences it is possible to obtain several different grades of clay from the same pit. Such conditions are apt to be the rule rather than the exception.

A not uncommon phenomon in many of the coastal plain formations is the occurrence of large lenses of clay, free from grit surrounded by beds of sandy clay or even sand.

DISTRIBUTION.

Clays and shales occur in practically every geological formation with the exception of the oldest. Most of those which are older than the Createaceous are hard and shale—like in their nature, while those of the Cretaceous and Tertiary on the other hand are usually soft and plastic, but deposits of Createaceous and also Tertiary shales are known.

The geological age of a clay or shale is no indication of its quality, and it is only of use at times for a means of comparison between two beds situated near each other, but even here it is not altogether a safe guide.

The geological relations of the clays of Alabama are treated somewhat more in detail below in a separate chapter.

PROPERTIES OF CLAYS.

These fall into two classes, i. e. (1) Chemical and (2) Physical. Two clays may correspond in their

widely in their physical characters, and therefore act entirely opposite when used for the manufacture of clay products.

Pure clay or *kaolin* would be composed entirely of *kaolinite,* the hydrated cilicate of alumina. These two terms are often confounded and it is well to empahasize the fact that kaolinite refers to the mineral species, while the term kaolin is applied to the mass. Pure kaolin has not thus far been found, although deposits containing as much as 98 per cent. of it are known, and the other two per cent. consists of foreign matter. The kaolin therefore contains a variable amount of mineral impurities mixed in with the kaolinite or the clay substance, as it is some times called, and these impurities may affect both the chemical and the physical properties to a variable extent, depending upon the quantity and the kind of them present. The clay substance is always present but in a variable amount, and it stands in no direct relation to the plasticity, except in so far that the latter is lost when the combined water is driven off.

The amount of clay substance in clays ranges from 5 or 10 per cent. to 98.5 per cent.

The chief impurities in kaolin are quartz, feldspar and mica, but in other clays the number of mineral species present may indeed be large.

CHEMICAL PROPERTIES.

The chemical composition of a clay directly influences its fusibility, and the color to which it burns.

The compounds which may be found in clay are silica, alumina, iron oxide, lime, magnesia, potash, soda, sulphuric acid, phosphoric acid, manganese oxide and organic matter. Compounds of chromium and vanadium may also be present at times in small amounts. All of these substances are not present in every clay, but most of them are.

Pure clay would contain silica, alumina and combined water, but the purest clay known commonly contain at least traces of iron oxide, lime and alkalies.

Alumina, organic matter and water are practically the only non-volatile constituents, which do not exert a fluxing action on the clay in burning, and the intensity of this fluxing depends partly on the amount of fluxes, and partly on the temperature at which the clay is burned.

It is the custom to divide the impurities of clay into those which are fluxing, and those which are non-fluxing.

Pure clay is very refractory. The kaolinite composing it contains two molecules of silica and one molecule of alumina. A higher percentage of silica tends to increase the fusibility up to a certain point, provided it is in a finely divided condition. above this point the refractoriness of the clay increases steadily with the addition of silica.

Other substances are far more powerful fluxes than the silica however, and these fluxes contain not only elements but also definite chemical compounds or mineral species.

The influence of fluxes increases not only with the amount present but also with the state of division, they being more active, the more finely they are divided. If the fluxing material is present in large grains, these will only exert a fluxing action on their upper surface, while the single grains alone will for a while act more like quartz grains i. e. as diluents of the shrinkage. The minerals which may be present and serve as fusible impurities are commonly mica, feldspar, hornblende, pyroxene, garnet, quartz, calcite, gypsum, iron oxide and manganese, and the elements contained in these constituting the active fluxing agents are alkalies, iron oxide, lime and magnesia.

Opinions differ somewhat in regard to the order of their relative effectiveness, but it is probably given above, the alkalies being the strongest.

The amount and kind of fluxes which it is desirable for a clay to contain depends on the use to which it is to be put. If a vitrified ware is desired then the fluxes should be present in appreciable amount, say 10 to 20 per cent., depending upon the relativestrength

of the fluxing impurity. Refractory clays, on the other hand, should contain a low amount of fusible substances. Porcelain clays might have as high a percentage of fluxes as 5 or 6 per cent., provided they did not exert a coloring action on the clay.

ALKALIES IN CLAYS.

The alkalies usually contained in clays are potash, soda and ammonia.

Ammonia is a very common constituent of moist clay and is absorbed by the latter with great avidity; indeed it is largely responsible for the characteristic oder of clay.*

If the ammonia remained in the clay, it would act as a strong flux, but its volatile nature renders it harmless, for it passes off as a vapour at a temperature considerably below dull redness, and in fact may even volitilize with the moisture of the clay during the early stages of burning.

Potash and soda on the other hand, which volatilize only at a high temperature, are present in almost every clay from the smallest amount up to 9 or 10 per cent. and of these potash is by far the commoner of the two. Their variable percentage may be caused by the presence of more or less undecomposed feldspar, of which orthoclase, the common species. has nearly 17 per cent. of potash while the other feldspars contain varying amounts of soda.

These alkalies may be present in the clay in the form of either soluble or insoluble compounds, the latter being represented by feldspar, mica, or other minerals, while the soluble ones are usually the result of their decomposition.

Soluble alkaline compounds may be found in almost any clay. but they are rarely present in large amounts, and their chief importance lies in the fact that they are often responsible for the formation of an efflorescence or white coating on the surface of the ware, they having become concentrated on the surface by the

*F. Senft, Die Thon Substanzen, p. 29.

evaporation of the moisture of the clay. They may be rendered insoluble by the addition of chemicals to the clay. In addition to its unsightliness the efflorescence may interfere with the adhesion of a glaze applied to the surface of the ware.

Soluble alkaline sulphates are powerful fluxes and they also cause blistering of the ware, if the clay is heated sufficiently high to decompose the compound and permit the escape of sulphuric acid gases.

In some clays containing sulphate of iron, this compound may be decomposed by chemical reaction taking place in the clay; the sulphuric acid, which is thus set free, is apt to attack the alumina of the clay substance and if potash, soda, or ammonia is present there is formed an alum of potash, soda or ammonia, which can often be detected by the taste which it imparts to the clay.

Insoluble alkaline compounds. Feldspar and mica which are the commonest of rock forming minerals are the two important sources of insoluble alkaline salts in the clay.

The feldspars are complex silicates of alumina and potash, or alumina, lime and soda. Orthoclase is the only species furnishing potash and contains about 17 per cent. of it while the lime-soda feldspars have from 4 to 14 per cent. of soda depending on the species.

Orthoclase is the common feldspar, and next to it come albite and oligoclase with 12 and 14 per cent. of soda respectively.

The micas are complex silicates of alumina with either lime or magnesia or potash. Muscovite, the common species, contains nearly 12 per cent. of potash, and may at times also contain soda. While the potash feldspar fuses completely at about 2300° Fahr., the potash mica alone is very refractory and unaffected by a temperature of 2550° Fahr., and though it probably serves as a flux, it is not definitely known at just what temperature its action begins.

The alkaline silicates on account of their fluxing properties are frequently at an advantage, especially if in the form of feldspar, as they serve in burning to

bring the particles of the clay together into the dense hard body, and also permit of the ware being burned at a lower temperature. If present in kaolins to the extent of several per cent. it is no detriment, provided no iron is present; an excess of feldspar, however, when added to a white burning clay will tend to produce a creamy tint.

In the manufacture of porcelain, white earthen ware, encaustic tiles and other products made from kaolins or white burning clays, and having a white body, which is impervious, or nearly so, the alkalies for the fluxing of this body are added in the form of feldspar.

Much feldspar is mined in this country for potters use, but all of it is the ortholase or potash feldspar.

IRON COMPOUNDS IN CLAYS.

Iron is not simply a fluxing impurity, but it is also the great coloring agent of clays in either their burned or unburned condition, and furthermore when in the form of the hydrated oxide or limonite it may serve to increase the absorbtive power of clay. *

The compounds in which iron may exist in the clays are as follows: Oxides:—limonite, hematite, magnetite, ilmenite. Silicates:—mica, hornblende, garnet, etc. Sulphides:—pyrite and marcasite. Sulphate:—melanterite. Carbonate:—siderite.

The iron oxides, limonite and hematite, are present in all clays, and may be introduced by percolating waters or be set free by the deccomposition of any of the iron-bearing silicates which the clay may contain. Not infrequently they are distributed through the clay in a very finely divided condition, or may form a thin film around the other mineral grains. Limonite tends to color the clay (unburned) brown or yellow, while hematite imparts a red color to it, and carbonate of iron may give gray tints.

The more sandy the clay the less the amount of the

* A. E. Smith, Alabama Geological Survey, Agricultural Report, p. 45.

limonite required to produce any given intensity of color.

Mica is found in most clays, and hornblende and garnet are probably wanting in few, while the pyrite is often present in many clays, especially in stoneware and fire clays, its yellow, glittering, metallic particles being easily recognizable. When large, the lumps of pyrite can be extracted by hand-picking, but if very small, they can only be separated by washing. Under weathering influences the pyrite changes to sulphate of iron. In all of the iron-bearing minerals the iron is present in either the ferrous or the ferric stage of oxidization, and the fusibility of the clay is influenced somewhat by this fact, for ferrous compounds are more easily fusible than ferric ones. In the burning of the clay the ferrous salt will be converted into the ferric state, provided the action of the fire is oxidizing. But if it is reducing the clay will fuse at a lower temperature.

The action of weathering agent in nature is often sufficient to oxidize the iron in clays so that more ferric than ferrous iron will be found in most of them. This change is often noticeable in many clay banks where the upper, and at times more porous layers, are colored red or yellow, while the lower layers are blue or bluish gray.

It should be noticed, however, that a gray color may be produced by the presencce of organic matter, and the same material present in a dense clay, to which the air can not get access, may serve to retard the oxidation of the iron. Whenever iron exists in clay in combination with silica it is present probably as a complex silicate, for pure ferric silicate is very rare in nature.

Ferric hydrate increases the absorbing power of clay for both gases and liquids, but it as well as the carbonate change to the oxide in burning.

The general tendency in burning is to convert the iron compounds into ferric oxides, provided a certain temperature, depending on the fusibility of the clay, is not exceeded, for in every clay the iron seems to re-

turn to the ferrous condition as the point of vitrification is approached. This change is accompanied by a liberation of oxygen, which is responsible for the active swelling and blistering of the clay, which takes place as the point of viscosity is approached.

If treated to an oxidizing fire, the presence of ferrous salts in clay may not be considered, provided the heat is raised high enough to oxidize them, but the rapidity w'th which the temperature is raised is important, for when the heat is increased rapidly the outer portion of the clay tends to shrink and become dense before the air has had time to enter and oxidize the iron in the center of the clay body, the latter remaining in ferrous state. This is the cause of black cores sometimes seen in bricks whose exterior is red.

Unburned clay may be yellow, blue, brown, red or gray in color, depending on the relative amount of ferrous and ferric salts present, for iron is the one element above all others which by itslf colors clays.

The same variety of shades and colors may be produced in burning. Ferrous oxide alone produces a green color when burned while ferric oxide alone may give red or purple, and mixtures of the two may produce yellow, cherry red, violet, blue and black.*

Segar found that combinations of ferric oxide with silica had a red or yellow color§ wh'le similar compounds of the ferrous salts showed blue or green.

The color to which any given clay burns may also depend on the intensity of the firing. Thus with moderate burning the iron may color a clay yellow or yellowish red, with harder firing this will pass into deep red, and on still more intense heating to blue or black, this latter color is to be seen on breaking open the arch brick in many kilns, but the surface of these same brick may also get black, due to ashes and cinders from the fire sticking to them.

The amount of ferric oxide permissible or desirable depends on the use to which the clay is to be put.

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*Keramik, p. 256.

§ Notizblatt, 1874, p. 16.

The clays which are used for making white ware should not contain over one per cent ferric oxide. And those with even three-quarters of one per cent. are apt to burn grayish at a high temperature, such as 2700 deg. Fahr. It is true that the reddish coloration of a small percentage of iron would be neutralized if any excess of carbonate of lime were present, but in this case even we should not get a pure white tint, but a yellowish one.

Brick clays should contain sufficient iron oxide to give a good red color to the ware when burned.

The bleaching of the iron coloration by the presence of lime will be mentioned later, an excess of alumina also tends to exert a decolorizing action upon the iron contained in the clay.

LIME IN CLAYS.

Lime is a most wide-spread constituent of clays, and occurs either in a finely divided state or else in the form of pebbles. An excess of lime in the clay in the former condition causes it to pass into marl, and in certain regions such clays are extremely abundant.

Lime may occur in clays either as a constituent of *silicate* minerals such as feldspar; in the form of *carbonate* as exampled by calcite or dolomite; or thirdly it may be present as a *sulphate*, which is the mineral gypsum.

The first two classes of compounds include minerals which are primary constituents of the clay, but the third type, gypsum, is usually of secondary origin, being the result of chemical processes, which took place in the clay mass.

The condition of lime is important, for in one case, it may be desirable, and in another it may do injury.

The presence of lime as a constituent of some silicate mineral is not infrequent, especially if the clay has been derived wholly or in part from crystalline rocks, such as gneisses and granites. The common feldspar, orthoclase, contains no lime, but the other species of feldspar do, and in addition there are other lime bear-

ing silicates which are apt to be met with in most of the impure clays.

When present as a silicate, lime acts as a flux, and is less liable to exert a decolorizing action on the clay than carbonate of lime. Bleaching action is caused by the formation of a double silicate of iron and lime, when the clay reaches a temperature approaching vitrification, and the color developed is either yellow, or yellowish green, according to the intensity of the firing.

Carborate of lime is an abundant constituent of some clays, and its presence, if over three or four per cent., can usually be detected by the effervescence which is producd when muriatic acid is poured on the clay. This compound of lime is far more injurious than the silicate, although, if present in the clay, in a finely divided condition. it may not only be harmless but even desirable, provided there is not an excess of it, for clays with as much as twenty to twenty-five per cent. of lime carbonate have been used for making common or even pressed brick and somtimes earthenware. It is well, however, to try and keep the amount lower than this if possible. Highly calcareous clays have often found a use in making of slip glazes.

If the carbonate of lime is present in the form of pebbles, a most undesirable effect is produced, for it is well known that when heated to redness, the compound is broken up into oxide of lime and carbonic acid gas; this oxide of lime, when cooled, absorbs moisture from the atmosphere and slakes, the result being a swelling of the material and a consequent splitting of the brick. Now if the clay be heated to a temperature sufficent to decompose the carbonate of lime, but not high enough to make it unite with any free silica present, the lime of course slakes on cooling. It is consequently imporatnt either to burn the clay sufficently or remove the lime pebbles from the clay by screening or by some other method before using.

For a high grade ware, calcareous clays are seldom employed, but in the manufacture of brick and terra-

cotta, they are frequently utilized either because no others are available or to obtain a buff colored ware.

Some soft body porcelains have an appreciable amount of lime, much of the Hungarian containing from five to fifteen per cent. of CaO.* The bone china made in England at the present day also contains lime and some white earthen ware manufacturers use lime instead of feldspar.

Much buff ware is now made from semirefractory clays, which, on account of their low percentage of iron, burn to a creamy color.

The one objection to highly calcaeous clays is that the points of incipient fusion and vitrification (see Fusibility of Clays) lie so close together that it is not safe to burn them hard without running the risk of fusing them. Experiments have shown however, that it is possible to separate these two points, by the addition of quartz and feldspar to the clay, of sand containing a large percentage of these two minerals.

In addtion to lowering the fusibility of clay, lime also affects the fusion and absorptive power, thus Segar found§§ that limy or marly clays required usually only twenty to twenty-four of water to convert them from a dry condition to a workable mass, whereas other clays needed twenty-eight to thirty per cent. of water to accomplish the same result. In burning the calcareous clays have not only their combined water to lose, but also the carbonic acid gas, and consequently the bricks are more apt to be light and porous unless they can be burned to vitrification. The shrinkage of calcareous clays is also less than that of others, and it sometimes happens that this shrinkage is not only zero, but that the brick even swells.

Many clays contain lime in the form of gypsum, the hydrated sulphate of lime. It generally results from the action, on carbonate of lime, of sulphuric acid set free by the oxidation and leaching of pyrite in the clay.

*Sprechsaal, 1896, p. 2.

§ Hecht, Thonindustrie Zietung.

§§ Thonindustrie Zietung, 1877, p. 131.

When in large amounts, gypsum discloses its presence by the formation of transparent crystals or crystallne masses, whose surface shows a pearly lustre; at other times it forms as parallel fibres which fill cavities or cracks in the clay. Gypsum may prove to be a very injurious impurity even when in small amounts, especially if the clay is not burned to vitrification.

In the first place it serves as a fluxing impurity, secondly, it is dissociated at high temperatures, and the escape of the sulphuric acid causes blistering of the ware, and thirdly, although nearly insoluble in water, nevertheless small amount of it may be brought to the surface of the ware in solution by the evaporation of water and there left in the form of a white coating.

Kaolins commonly have very little lime, but in many common brick and stone ware clays, it frequently ranges from one to three per cent.

MAGNESIA IN CLAYS.

Magnesia is a constituent of many minerals, and yet it seldom occurs in large quantities, the amount in most of them rarely exceeding two per cent.

It may occur in the same classes of compound as lime i. e. *silicates,* such as mica, chlorite, hornblende and pyroxene; in *carbonates,* such as dolomite and magnesite; and in *sulphates,* such as epsom salts.

The silicates are, no doubt, the most important source of magnesia, for mica, chlorite, and hornblende are all common constituents of the more impure clays. They are scaly minerals of complex composition and contain from 1 to 25 per cent. of magnesia. The mica is frequently to be noticed in the sandy seams of the clay, while the other portions of the deposit may be quite free from it. Hornblende and pyroxene are to be looked for mostly in clays derived from the dark colored igneous rocks, and indeed the two latter minerals not only furnish magnesia, but by their decomposition furnish also iron oxide to the clay.

Dolomite, the double carbonate of lime and mag-

nesia, may be present in some clays derived from magnesian limestone, while the sulphate of magnesia or epsom salts when present, may aid in the formation of a white coating on the surface of the ware; its presence can sometimes be detected by the bitter taste which it imparts to the clay.

The effects of magnesia in clays are considered to be the same as those produced by lime.

SILICA IN CLAYS.

Three types of silica may be recognized in clay, i. e.

1st. Quartz.

2nd. That which is combined with alumina and water in kaolinite.

3rd. That which is combined with one or more bases, forming silicate minerals, such as feldspar, mica, etc.

In chemical analysis the first and third are sometimes grouped together under the name of sand, or at times erroneously spoken of as free silica.

The sand is practically insoluble in sulphuric acid and caustic soda and this fact is utilized in the rational analysis of clay.

Few clays, so far as known, are free from quartz, but it is present in variable amounts in different ones. A minimum of .2 of one per cent. has been recorded from New Jersey* while the average in the Woodbridge fire clays is five per cent.

In the Missouri flint clays, a minimum of .5 of one per cent., is recorded, while the sand percentage is 20 to 43 per cent. in the St. Louis fire clays, and 20 to 50 per cent. in the Loess clays.§

27 samples of Alabama clays contained from 5 to 50 per cent. of insoluble residue.

70 North Carolina clays had from 15.75 per cent. to 70.43 per cent. of insoluble residue.

In European clays similar variations are observable. The most important effect of silica or sand is

*G. H. Cook, Clays of New Jersey, 1878, p. 273.

§ Wheeler, Missouri Geological Survey, XI, page 54.

that as it increases the plasticity, tensile strength, and air shrinkage tend to decrease. In fact silica especially if present abundantly in large grains, may cause an expansion of the clay in burning.

Quartz serves as a flux at very high temperatures, but at lower ones it tends to increase the refractoriness of the clay, and this property is governed some what by the size of the quartz grains and the amount of fluxing material which will fuse at lower temperatures.

Sand acts as a diluent of the shrinkage in air drying and also in burning up to a certain point depending upon the fusiblity of the constituent grain.

In the burning of low grade clay, the quartz grains tend to act as a skeleton and preserve the form of the mass, while the fluxing impurity by their fusion bind the whole together.

TITANIC ACID IN CLAYS.

Titanium generally occurs in clays in the form of the mineral rutile (titanic oxide). It has always been looked upon as a rare element and a non-detrimental impurity, but the idea of its rarity has probably resulted from the fact that it is not commonly determined or looked for in the ordinary quantitative analysis. Its effect on the fusibility of clay has never been thoroughly understood, although it has seemed probable that its action was somewhat analogous to that of silica.

The experiments of Seger have indicated that when a hundred parts of kaolin and 6.65 per cent. titanic oxide were heated to above melting point of wrought iron, the resulting mass was densely sintered, and showed a dark blue fracture.

13.3 per cent. added to a hundred parts of kaolin gave a deep blue enamel at the same temperature, while an equal amount of kaolin with the addition of 10 per cent. of silica burned to a snow white mass at the same temperature and did not fuse. From this it will be seen that the actions of titanium and silica at high temperatures are not exactly alike.

ORGANIC MATTER IN CLAYS.

Organic matter affects not only the color of clay but also its plasticity, absorptive power and tensile strength.

It is present in clays either in the form of finely divided pieces of plant tissue or larger fragments of stems or leaves, which settled in the clay during its deposition, and have since become wholly or partly converted into lignite. All surface clays contain plant roots, but these exert little effect other than to aid the percolation of surface waters.

Clays colored by organic matter and containing no iron, burn white, as the plant tissue burns off at bright redness; if such a clay, however be heated too quickly, the surface of it becomes dense before all of the organic matter has had opportunity to escape from the interior, and the latter remains dark colored.

Organic matter may also mask the presence of iron so that the clay, instead of burning white, will burn red at a temperature of above that at which the organic matter passes off, below that temperature the vegetable matter will tend to keep the iron reduced. The clay from Fernbank, Lamar County, Alabama, contains 6.40 per cent of ferric oxide, and 2 to 2½ per cent of organic matter, but in the raw material, the latter hides the former. Organic matter exercises an important influence on the plasticity, often increasing it to an enormous degree, it also tends to elevate the tensile strength, the clay just mentioned showing 185 pounds per square inch, but high plasticity does not always indicate the presence of much organic material.

In the weathering of clays organic matter by its slow oxidation, aids in breaking them up by the escape of the carbonic acid gas.

WATER IN CLAYS.

All clays contain two kinds of water:—

1st. Hygroscopic water or moisture (mechanically absorbed).

2nd. Chemically combined water.

The *moisture* in air dried clays may be as low as .5 per cent. and reach 30 to 40 per cent. in those freshly taken from the bank. In the air dried specimens in the Alabama samples tested, it varied from .12 per cent. to 3.4 per cent.

In air drying most of the moisture is expelled, and this is accompanied by a shrinkage of the clay, which, in the case of the Alabama samples, was usually from 2 to 7 per cent., but in one case it reached 14 per cent.

The air-shrinkage of the clay ceases however before all the moisture passes off, the reason for this being that the shrinkage ceases when the clay particles have come in contact with each other, but there may still remain spaces between them which hold the water by capillarity, and the brick will contiue to lose weight but not in size, until all of this water has been driven off.

In practice it is this latter portion of the moisture that evaporates during the first period of the burning known as water smoking.

The air shrinkage of a clay varies with the nature of the material. Sandy clays usually show the least shrinkage, and of this kind the coarse grained ones diminish the least in size, while highly plastic clays usually show a high contraction in volume.

The amount of water, which a dry clay needs to develop its maxium plasticity is a variable quantity. Plastic clays absorb a large amount, but a lean clay and fine grained one may do the same. As a very general rule it may be stated that lean clays absorb from twelve to twenty per cent. of water, while fat clays anywhere from twenty to fifty per cent., and the more water a clay absorbs the more it has to part with in drying and the greater will be its shrinkage.

If green ware is dried too rapidly it may split, not only from differential shrinkage between the exterior and the interior surface, but the rapid escape of steam may, in the first stage of the burning, tend to burst the ware.

Highly aluminous clays do not always absorb the most water, nor are they the most plastic, and some

clays low in alumina and high in organic matter are not only highly plastic but also absorb a large quantity of water.

In the manufacture of clay products the moisture is partly expelled by exposing the ware to the sun or putting it in heated tunnels or rooms, while the last traces of moisture are driven off in the early stages of burning.

Moisture may play another important and injurious role in clay working by its tendency to dissolve the soluble salts in the clay and bring them to the surface in drying, where they are left in the form of a white coating. It may also permit the acids which are contained in the fire gases of the kiln, to act on the mineral ingredients of the clay, and thus form soluble compounds, especially clorides and sulphates.

Combined water is present in every clay. In pure kaolin there is nearly 14 per cent. of it, in other clays the percentage depends on the amount of clay base and the presence of other hydrated minerals, such as limonite.

Combined water is driven off at a low red heat, and when this occurs the clay suffers an additional shrinkage. It is a curious fact that although the combined water does not determine the degree of plasticity of the clay, nevertheless when once driven off the clay can no longer be rendered plastic. The greater the amount of combined water, the greater the shrinkage, and in the burning the Alabama clays it varied from $2\frac{1}{2}$ to 12 per cent.

PHYSICAL PROPERTIES OF CLAYS.

These are fully as important as chemical ones, if not more so, plasticity for instance being a character of enormous value.

The physical characters which are of the most importance from the practical standpoint, are plasticity, fusibility, shrinkage, tensile strength, slaking, absorption and density.

PLASTICITY.

This is the property by virtue of which a clay can be moulded into any desired form when wet, which shape is retained by it when dry.

Just what the cause of plasticity is still remains to be definitely proven, although several theories, some of them very reasonable ones, have been advanced. It is an exceedingly variable property and we can find all stages in the transition from the highly plastic clay to the slightly coherent sand. Clays, which posses little plasticity are said to be lean, while highly plastic ones are called fat.

Pure or nearly pure kaolins are nearly always lean, while clays low in kaolinite may be highly plastic, thus for instance the clay from Chalk Bluff, and the stoneware from Prattville, containing respectively 36.50 and 26.98 per cent. of alumina are both lean, while the clays from Fayette Court House and Fernbank containing only 19.68 and 13 per cent. of alumina respectively are both highly plastic.

Cook has shown that the plasticity of some kaolins may be increased by grinding them, the result being to tear apart the little particles of clay which were bunched or clustered together and thus permit a greater mobility of the grains or scales of clay over each other.

Mica decreases the plasticity of clay, and if, in a finely divided condition, tends to make it flaky when wet.

Plasticity, whatever its cause, is an important property from a commercial standpoint and highly interesting from a scientific one. The amount of water required to develop the maximum plasticity varies. If too little is added the clay cracks in moulding and is stiff and hard to work; if too much is mixed in with the clay it becomes very soft and retains its shape with difficulty. Lean clays usually require less water to produce a workable mass than plastic ones.

The Alabama clays require from 25 to 30 per cent. of water to develop their maximum plasticity.

TENSILE STRENGTH.

The tensile strength or the binding power of a clay often stands in relation to its plasticity, but not always. It exerts an important effect in connection with the cracking of the ware in drying. The common method of determining it is to form the plastic clay into briquettes of the same shape as those used in the testing of cement. When air-dried they are tested in the regular cement testing machine, and their tensile strength per square inch is determined. Before breaking, the cross section of the briquette must be carefully measured, as the clay shrinks in drying and the tensile strength per square inch has to be calculated from this sectional area.

The tensile strength of air-dried clays is extremely variable. In kaolins it is from 5 to 10 pounds per square inch; in brick clays 60 to 75 pounds per square inch and even 100 pounds; in pottery clays from 150 to 175 pounds.

Some very plastic clays show as much as 200 and 300 pounds per square inch, and a tensile strength of even 400 pounds has been recorded.

The strongest Alabama clay were the highly plastic one from Chalk Bluff, which had a maximum tensile strength of 384 pounds per square inch, while the Choctaw County one showed only 5 pounds per square inch.

The Alabama clays were all ground and passed through a thirty mesh sieve before testing.

Very fine grained clays seem to be lacking in tensile strength as they are in plasticity.

SHRINKAGE.

All clays undergo a shrinkage in drying and an additional shrinkage in burning, the first is known as air —, the second as fire-shrinkage. Some clays shrink most in drying, others most in burning, and consequently the amount is variable and depends on the amount of water absorbed, on the amount of lime in

the clay, the quantity of organic matter, the size of the grain, and the amount of combined water.

The amount of water absorbed, and the texture influence the air-shrinkage which begins as soon as the water commences to evaporate from the clay. It has already been mentioned that a clay keeps on losing in weight after the shrinkage has ceased, and this fact is well shown by the following experiments on some Alabama samples.

The clay was from property of J. C. Bean, Sec. 31, T. 20, R. 11 w.

After moulding, the clay weighed	35.698	grams.
At end of 24 hours the shrinkage was 11½ per cent. and the weight	30.891	"
At end of 48 hours, shrinkage 12 per cent., weight	29.588	"
At end of 6 days, shrinkage 12 per cent., weight	29.460	"
At end of 8 days, shrinkage 12 per cent., weight	29.140	"
At end of 12 days, shrinkage 12 per cent., weight	29.093	"

Throughout this period the clay was kept exposed to a tempertare of 70° Fahr.

The shrinkage is generally equal in all three directions, and consequently only the linear shrinkage is given. The greater the shrinkage of a clay the more danger there is of its cracking and warping in burning, and when there is any apprehension that this may occur, an attempt is made to prevent it by the addition of grog (burned clay) which diminishes the shrinkage.

Coarse grain clays having larger pores permit the water to escape more rapidly, and hence can be dried more quickly than fine grained ones, from which the water can not very readily escape. If the drying of fine grained clays is hastened, the surface shrinkage is more rapid than that of the interior and cracking ensues. We might perhaps expect that on account of their greater porosity, the fine grained clays would absorb more water, and consequently shrink more in drying. but the Alabama clays do not always bear out this fact.

The fire shrinkage generally commences when the

combined water begins to pass off, and it may be just as variable as the air shrinkage. In fine grained clays, as those from near Prattville, the shrinkage from burning was found to be comparatively uniform, while on the other hand moderately fine grained kaolin from Rock Run shrank more rapidly as it approached the temperature of vitrification.

Sometimes the clay instead of shrinking during the burning appears to expand; and this is especially the case with very quartzose ones, for the quartz has the property of expanding at high temperatures. This expansion of siliceous clays may sometimes be responsible for the presence of cracks in the burned ware.

As the addition of quartz to diminish the shrinkage also tends to decrease the tensile strength of the clay, there will be a certain limit beyond which it must not proceed.

Organic matter and combined water tend to increase the shrinkage in burning, but lime has the oposite ten lency.

Clays containing a large amount of feldspar will, in stead of showing a steady shrinkage up to the temperature of complete vitrification, often exhibit a temporary increase of volume when the fusing point of the feldspar is reached.

The shrinkage of most clays in burning does not proceed regularly and steadily up to the temperature of vitrification, for some clays attain their maximum density at a comparatively low temperature, below that at which thev vitrify. Thus the plastic clay of J. C. Bean, near Tuscaloosa, attains its maximum shrinkage at cone 5, but does not vitrify until cone 27.

Between the point at which the moisture seems to pass off and that at which the combined water begins to escape, the clay shrinks little or none at all, and

consequently the heat can be raised rapidly in this interval, but above and below these two points it must proceed slowly to prevent cracking or warping of the ware.

FUSIBILITY OF CLAYS.

It can be said in general, that other things being equal, the fusibility of a clay will increase with the all the fuxing impurities do not act with the same inapproximate statement however, for in the first place all the fluxing impurities do not act with the same intensity, and of two clays containing the same amount and kind of fluxes, that one which has the finer grain will usually fuse at the lower temperature, in addition to this the condition of the fire, whether oxidizing or reducing, also exerts an effect.

White mica tends to increase the refractoriness of a clay, and to exert very little fluxing action even at moderatly high temperatures.

As a clay is gradually heated, it not only shrinks, but also begins to harden. At the temperature at which the combined water begins to pass off, the impure clays acquire such a degree of hardness that they can no longer be scratched by a knife; but in the case of purer clays, the temperature must be raised much higher to obtain this same degree of hardness. This condition is brought about by the clay particles beginning to soften under the action of the heat, in other words it represents the very first stages of melting or incipient fusion, and in this condition the clay particles stick to each other, and bind the whole together into a solid mass. In clays which have been burned to incipient fusion, the particles are however still recognizable. If the temperature be increased, a variable amount, depending upon the clay, the result is

that all of the particles become sufficently soft to permit their adjustment into a condition of greater compactness, leaving no interspaces, or in other words, the clay becomes impervious. This condition is spoken of as virtification, or complete sintering. The particles of the clay are no longer recognizable, and the maximum shrinkage has been reached. With a further elevation of the temperature the clay mass fusses completely, and becomes viscous or flows.

We therefore can recognize three stages in the burning of the clay, i. e., incipient fusion, vitrification and viscosity.*

The points of incipient fusion and viscosity may be within 75 degrees Fahr. of each other as in calcareous clays, while in some fire clays they may be as much as 500 or 600 degrees apart, and furthermore the point of vitrification does not necessarily lie midway between the two.

Most clays show a difference of from 200 to 400 degrees Fahr. between the points just mentioned, and it can be easily understood the farther apart these two points, the safer will it be to burn the clay, for it is not always possible to control a kiln within a range of a few degrees of temperature, and therefore in burning a mass of ware to vitrification if this point lies too near that of viscosity, there is danger of overstepping it and reaching the latter.

The fusibility of a clay depends on:

1. The amount of fluxes.
2. Size of the grain of the refractory and the non-refractory constituents.
3. The condition of the fire, whether oxidizing or reducing.

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*These three terms have been suggested by H. A. Wheeler, Vitrified Paving Brick, 1895.

Attempts have been made to express the relative fusibiliy of clays numercally, and this number has been called the *refractory quotient* by Bishop* and the fusibility factor by Wheeler.§ In both cases, the figure is obtained by using the non-fluxing elements of the clay for the numerator, and the fluxing impurities as a denominater; and in the case of the second formula, the fineness of the grain was also taken into consideration. As this mode of expressing the fusibility has not come into general use, the reference is simply given here.

On the other hand, it is customary to express the fusibility of the clay in degrees of temperature, and this temperature is measured by one or another form of pyrometer, whose principle depends on the fusion of alloys or single metals; thermo-electricity; fusion of an artificial mixture; spectro photometry; expansion of gases or solids; etc. Many of these are only applicable at lower temperatures, others are largely influenced by the personal equation, and only two or three of the most important will therefore be mentioned here.

THE THERMO-ELECTRIC PYROMETER.

Le Chatelier's Thermoelectric pyrometer depends on the measurement of a current generated by the heating of a thermo-pile. The latter consists of two wires, one of platium, the other an alloy, 90 per cent. platinum and 10 per cent of rhodium, twisted together at their free ends for a distance of about an inch, while the next foot or two of their lenth is enclosed in a fire clay tube so that when the couple is inserted into the

*Die Feuerfesten Thone, p. 71, 1876.

§ English and Mining Journal, March 10, 1894.

furance only the end which is held near the body whose temperature is to be measured, will receive the full force of the heat. The two wires connect with a galvanometer, the deflection of whose needle increases with the temperature at the point of the free end of the wire couple. As at present put on the market, the thermo-electric pyrometer, costs about $180 and this, together with the delicacy of the galvanometer, has tended to restrict its use. There is no reason however why one should not be made and put on the market for a much lower price. It is not necessary that the recording instrument should be in immediate vicinity of the kiln, but it may be kept in another room where it is safe from dust and rough handling, and wires can extend from there to the kiln. This pyrometer is considered to be accurate to within 10 degrees Fahr.

SEGER PYRAMIDS.

These consists of different mixtures of kaolin and fluxes, which are compounded so that there shall be a constant difference between their fusing points. Segar's series were numbered from one to twenty, and the difference between any twoiconsecutive numbers is 36 degrees Fahr. A later series introduced by Cramer runs from .01 to .022 with a difference of 54 degrees Fahr. between their fusing points, and in addition the higher numbers in the Segar series have been extended from number twenty up to number thirty-six. As these cones have been recently recalibrated, the fusing points of the various numbers together with their composition is given herewith.*

* Taken from a recently issued circular of Thon industrie Saboratorium in Berlin, where the cones are and were originally made.

No. of Cone.	Composition.			Fusion Point Cent.	Fusion Point Fahr.
022	0.5 Na_2O 0.5 PbO	—	2 SiO_2 1 B_2O_3	590	1094
021	0.5 Na_2O 0.5 PbO	0.1 Al_2O_3	2.2 SiO_2 1 B_2O_3	620	1148
020	0.5 Na_2O 0.5 PbO	0.2 Al_2O_3	2.4 SiO_2 1 B_2O_3	650	1202
019	0.5 Na_2O 0.5 PbO	0.3 Al_2O_3	2.6 SiO_2 1 B_2O_3	680	1256
018	0.5 Na_2O 0.5 PbO	0.4 Al_2O_3	2.8 SiO_2 1 B_2O_3	710	1310
017	0.5 Na_2O 0.5 PbO	0.5 Al_2O_3	3 SiO_2 1 B_2O_3	740	1364
016	0.5 Na_2O 0.5 PbO	0.55 Al_2O_3	3.1 SiO_2 1 B_2O_3	770	1418
015	0.5 Na_2O 0.5 PbO	0.6 Al_2O_3	3.2 SiO_2 1 B_2O_3	800	1472
014	0.5 Na_2O 0.5 PbO	0.65 Al_2O_3	3.3 SiO_2 1 B_2O_3	830	1526
013	0.5 Na_2O 0.5 PbO	0.7 Al_2O_3	3.4 SiO_2 1 B_2O_3	860	1580
012	0.5 Na_2O 0.5 PbO	0.75 Al_2O_3	3.5 SiO_2 1 B_2O_3	890	1634
011	0.5 Na_2O 0.5 PbO	0.8 Al_2O_3	3.6 SiO_2 1 B_2O_3	920	1680
010	0.3 K_2O 0.7 CaO	0.2 Fe_2O_3 0.3 Al_2O_3	3.50 SiO_2 0.50 B_2O_3	950	1742
09	0.3 K_2O 0.7 CaO	0.2 Fe_2O_3 0.3 Al_2O_3	3.55 SiO_2 0.45 B_2O_3	970	1778

No. of Cone.	Composition.			Fusion Point Cent.	Fusion Point Fahr.
08	0.3 K_2O, 0.7 CaO	0.2 Fe_2O_3, 0.3 Al_2O_3	3.60 SiO_2, 0.40 B_2O_3	990	1814
07	0.3 K_2O, 0.7 CaO	0.2 Fe_2O_3, 0.3 Al_2O_3	3.65 SiO_2, 0.35 B_2O_3	1010	1850
06	0.3 K_2O, 0.7 CaO	0.2 Fe_2O_3, 0.3 Al_2O_3	3.70 SiO_2, 0.30 B_2O_3	1030	1886
05	0.3 K_2O, 0.7 CaO	0.2 Fe_2O_3, 0.3 Al_2O_3	3.75 SiO_2, 0.25 B_2O_3	1050	1922
04	0.3 K_2O, 0.7 CaO	0.2 Fe_2O_3, 0.3 Al_2O_3	3.80 SiO_2, 0.20 B_2O_3	1070	1958
03	0.3 K_2O, 0.7 CaO	0.2 Fe_2O_3, 0.3 Al_2O_3	3.85 SiO_2, 0.15 B_2O_3	1090	1994
02	0.3 K_2O, 0.7 CaO	0.2 Fe_2O_3, 0.3 Al_2O_3	3.90 SiO_2, 0.10 B_2O_3	1110	2030
01	0.3 K_2O, 0.7 CaO	0.2 Fe_2O_3, 0.3 Al_2O_3	3.95 SiO_2, 0.05 B_2O_3	1130	2066
1	0.3 K_2O, 0.7 CaO	0.2 Fe_2O_3, 0.3 Al_2O_3	4 SiO_2	1150	2102
2	0.3 K_2O, 0.7 CaO	0.1 Fe_2O_3, 0.4 Al_2O_3	4 SiO_2	1170	2138
3	0.3 K_2O, 0.7 CaO	0.05 Fe_2O_3, 0.45 Al_2O_3	4 SiO_2	1190	2174
4	0.3 K_2O, 0.7 CaO	0.5 Al_2O_3	4 SiO_2	1210	2210
5	0.3 K_2O, 0.7 CaO	0.5 Al_2O_3	5 SiO_2	1230	2246
6	0.3 K_2O, 0.7 CaO	0.6 Al_2O_3	6 SiO_2	1250	2282

No. of Cone.	Composition.			Fusion Point Cent.	Fusion Point Fahr.
7	0.3 K_2O / 0.7 CaO	0.7 Al_2O_3	7 SiO_2	1270	2318
8	0.3 K_2O_3 / 0.7 CaO	0.8 Al_2O_3	8 SiO_2	1290	2354
9	0.3 K_2O / 0.7 CaO	0.9 Al_2O_3	9 SiO_2	1310	2390
10	0.3 K_2O / 0.7 CaO	1.0 Al_2O_3	10 SiO_2	1330	2426
11	0.3 K_3O / 0.7 CaO	1.2 Al_2O_3	12 SiO_2	1350	2462
12	0.3 K_2O / 0.7 CaO	1.4 Al_2O_3	14 SiO_2	1370	2498
13	0.3 K_2O / 0.7 CaO	1.6 Al_2O_3	16 SiO_2	1390	2534
14	0.3 K_2O / 0.7 CaO	1.8 Al_2O_3	18 SiO_2	1410	2570
15	0.3 K_2O / 0.7 CaO	2.1 Al_2O_3	21 SiO_2,	1430	2606
16	0.3 K_2O / 0.7 CaO	2.4 Al_2O_3	24 SiO_2	1450	2642
17	0.3 K_2O / 0.7 CaO	2.7 Al_2O_3	27 SiO_2	1470	2678
18	0.3 K_2O / 0.7 CaO	3.1 Al_2O_3	31 SiO_2	1490	2714
19	0.3 K_2O / 0.7 CaO	3.5 Al_2O_3	35 SiO_2	1510	2750
20	0.3 K_2O / 0.7 CaO	3.9 Al_2O_3	39 SiO_2	1530	2786

No. of Cone.	Composition.			Fusion Point Cent.	Fusion Point Fahr.
21	0.3 K_2O, 0.7 CaO	4.4 Al_2O_3	44 SiO_2	1550	2822
22	0.3 K_2O, 0.7 CaO	4.9 Al_2O_3	49 SiO_2	1570	2858
23	0.3 K_2O, 0.7 CaO	5.4 Al_2O_3	54 SiO_2	1590	2894
24	0.3 K_2O, 0.7 CaO	6.0 Al_2O_3	60 SiO_2	1610	2930
25	0.3 K_2O, 0.7 CaO	6.6 Al_2O_3	66 SiO_2	1630	2966
26	.3 K_2O, .7 CaO	7.2 Al_2O_3	72 SiO_2	1650	3002
27	.3 K_2O, .7 CaO	20 Al_2O_3	200 SiO_2	1670	3038
28		Al_2O_3	10 SiO_2	1690	3074
29		Al_2O_3	8 SiO_2	1710	3110
30		Al_2O_3	6 SiO_2	1730	3146
31		Al_2O_3	5 SiO_2	1750	3182
32		Al_2O_3	4 SiO_2	1770	3218
33		Al_2O_3	3 SiO_2	1790	3254
34		Al_2O_3	2.5 SiO_2	1810	3290
35		Al_2O_3	2 SiO_2	1830	3326
36		Al_2O_3	2 SiO_2	1850	3362

The theory of these pyramids is that the cone bends over as the temperature approaches its fusing point, and when this is reached, the tip touches the base. If the heat is raised too rapidly, those cones which contain much iron swell and blister and do not bend over, and the best results are obtained by the slow softening of the cone under a gradually rising temperature.

For practical purposes these cones are considered sufficiently accurate.

In actual use they are placed in the kiln at a point

where they can be watched through a peep-hole but at the same time will not receive the direct touch of the flame from the fuel. It is always well to put two or more cones in the kiln so that warning can be had not only of the approach of the desired temperature but also of the rapidity with which the temperature is rising.

In order to determine the temperature of a kiln several cones of separated numbers are put in,as for ex. .07, 1, and 5. Suppose .07 and 1 are bent over in burnng but 5 is not affected, then the temperature of the kiln was between one and five; the next time 2, 3, and 4 are put in, and 2 and 3 may be fused but 4 remain unaffected, indicating that the temperature reached the fusing point of three.

These pyramids have been much used by foregin manufacturers of clay products and are coming into use in the United States. Numbers .01 to 10 can be obtained for one cent each from Prof. E. Orton, Jr., Ohio State University, Columbus, Ohio.

It is rather difficult to compare the thermo-electric pyrometer with Seger pyramids and say that either one or the other is better. The latter are well adapted to judge the completion of the burning. That is it may take the same amount of heat to burn a certain ware to the proper condition, as it does to bend over cone 5,so that when the latter goes over the burning is done.

The cones do not however show whether the temperature of the kiln is rising steadily or fast at one time and slow at another, or again whether or not it may have dropped temporarily.

All of these last mentioned conditions are shown by the thermo-electric pyrometer, and a comparison of

conditions during burning, with the results obtained, may lead to a discovery of those conditions that will produce the best product.

CHEMICAL EFFECTS OF HEATING.

While the fusion of a clay may be looked upon in part as a chemical action, there are other changes which take place in the clay before the temperature of fusion is reached. These changes are:

The driving off of the chemically combined water.

The burning of the organic matter.

The change of limonite to hematite by the loss of its combined water.

The oxidization of pyrite to sulphate which by further heating loses its sulphur and is also converted into hematite.

The driving off of carbonic acid from any carbonates of lime or magnesia which may be present.

The general effect of these changes is first to make the clay more porous, but subsequently to increase its shrinkage, and in addition the color of the clay is changed.

A chemical interaction between the components of the clay only begins with incipient fusion.

SLAKING.

Clays, when thrown into water, break up more or less completely, or in other words, they slake. The process is simply one of mechanical disintegration, which, however, has important practical bearings. Some homogeneous clays on being immersed split into a number of angular fragments, while others flake off into scaly particles, while still others crumble down to a powder. This slaking action proceeds slowly or

quickly depending on the toughness or density of the clay. Some clays slake completely in two or three minutes, while others may be little effected by an immersion in water of an hour or two.

The practical importance of slaking is noticed first in the case of clays which have to be washed for marketing, for the quicker they fall apart when they are thrown into water, the more rapid and sometimes the more thoroughly will be the elimination of the impurities.

In the tempering the easy slaking of a clay is also of importance, permitting it to be more easily broken up and the more thoroughly mixed with water.

ABSORPTION.

This varies with the amount of organic matter, ferric hydrate, and the porosity of a clay, and increases with all three. As has already been stated the more water a clay absorbs the more it has to give off in drying and the more difficult it is, especially in the case of fine grained clays, to avoid cracking.

COLOR OF UNBURNED CLAYS.

Ferric oxide and organic matter are the two great coloring agents of the raw clay. Organic matter generally colors a clay gray, bluish gray, or black, while iron according to the condition of the oxide, or the presence of carbonate, may impart a red, yellow brown, or sometimes a gray color.

For any given amount of organic matter or ferric oxide, the coloration will be much more intense the more sandy the clay.

In general it may be said that, organic matter ex-

cepted, the purer clays are usually light colored, while the impure ones are yellow, red, or brown.

Organic matter however, frequently masks the iron coloration, and makes it often difficult to determine the refractory nature of the material. Some clays which burn perfectly white may be colored black by organic matter as in the case of the sand clay from Pegram. Ferrous compounds not infrequently impart a gray or bluish tint to clay, and at times the lower part of a clay bed may be gray while the upper portion is yellow or red, due to the oxidation of the iron contained in it.

THE MINERALOGY OF CLAYS.

Most clays are so fine grained that it is impossible to determine the mineral constituents with the naked eye, and their recognition even microscopically, is sometimes a matter of diffculty. At the same time however, there are certain minerals, which are either present in all clays or are to be found in a great many of them, and these will be mentioned in the order of their abundance.

KAOLINITE.

The mineral kaolinite is looked upon as the base of all clays, and while it is not wanting so far as we know in any of them, nevertheless, it is not as abundant as we have been apt to consider it, nor are the characteristic properties of clay wholly due to it.

Kaolinite, whose formula is Al_2O_3, $2SiO_2$, $2H_2O$, or silica 46.3 per cent., alumina 39.8 per cent., water 13.9 per cent is a white scaly mineral crystallizing in the monoclinic system, the crystals presenting the form of small hexagonal plates. Its specific gravity is 2.2

to 2.6 and its hardness is 2 to 2½. It is naturally white in color and plastic when wet but very slightly so. The microscope shows the kaolinite to be collected in little bunches which can be broken apart by grinding and thereby increasing the plasticity.*

Kaolinite is nearly infusible but a slight addition of fusible impurities lowers its refractoriness. A mass of kaolinite is called kaolin, and pure kaolin is practically unknown.

Many kaolins contain very minute scales of white mica, which under the microscope are hardly distinguishable from kaolinite. It is not to be inferred that kaolinite always occurs in hexagonal plates, for in some clays scales of six sided outline are almost wanting.

QUARTZ.

This mineral is present in sedimentary clays mostly in the form of rounded grains, and sometimes in crystals, while in residual clays the particles are most commonly angular. It is an extremely hard mineral, which will scratch glass and possesses a shell like or conchoidal fracture, it is practically not attacked by the common acids, but is affected by alkaline solutions. This is one of the few mineral components of clay which, at times, occurs in grains of sufficient size to be recognized by the unaided eye. It may be colorless but the surface of the grain is not infrequently stained by a thin film of iron oxide. Feldspar might be mistaken for it, but the latter will not scratch glass.

Flint or non-crystalline silica is sometimes present in clays. It usually has a muddy color and a conchoidal fracture.

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*G. H. Cook, Clays of New Jersey, Geological Survey, 1878.

Both quartz and flint are infusible at very high temperatures but the presence of other minerals may serve to flux them. Quartz tends to diminish the shrinkage of the clay, and if wanting it has to be added during the process of manufacture. Its addition also tends to decrease the plasticity.

CALCITE.

This mineral which is carbonate of lime, effervesces when moistened with muriatic acid, so that its presence in clay may often be detected by the addition of this chemical. Calcite is a soft mineral and occurs in the clay, either in the form of little rhombohedral or powdery particles. Clays, which contain a large amount of it in finely divided condition, are said to be marly, and in some clay deposits certain layers may contain a larger percentage of carbonate of lime than others. The carbonate of lime found in clays may be derived from particles of limestone in the clay if it is a sedimentary one, or from the decomposition of lime-soda feldspar in the case of either sedimentary or residual deposits. Percolating water may also introduce it into the clay.

GYPSUM.

Gypsum or the sulphate of lime is found in clay in the form of grains, needles, well developed crystals, or lamellar masses. It is so much softer than calcite that it can be scratched by the finger nail, often has a pearly lustre, is transparent, and does not effervesce when acid is poured on it. In hard burned brick gypsum simply acts as a flux, but in lightly burned ones

it gives rise to soluble sulphates which cause efflorescence.

MICA.

This mineral can be frequently detected by the naked eye, owing to its high lustre, even when it is present in the form of very minute scales. It is seldom absent in clays and is usually found to an appreciable extent in even the best kaolins, for on account of its scaly nature and lightness, it remains suspended in water for a long while and is consequently very hard to remove by washing; small amounts of white mica are rarely injurious.

Mica is usually found in those clays which have been derived from the breaking down of igneous or metamorphic rocks, such as granites, gneisses or schists, and two species are recognized in clay, i. e. biotite and muscovite. The former is a complex silicate of iron, magnesia, and alumina, and occurs as six sided plates or irregular scales usually of a dark color. As it easily decomposes with the formation of iron oxide, it is not so apt to be found in clays as the muscovite, which is more resistant to weathering. The muscovite is sometimes called potash mica, although it also contains a small amount of iron and magnesia; it is of silvery white or light brown color.

Mica decreases the plasticty of clay, and tends to make it flaky when wet, if in a finely divided condition.

White mica tends to increase the refractoriness of a clay, and to exert very little fluxing action, even at moderately high temperatures.

IRON OXIDE.

This, next to quartz, is perhaps the commonest mineral impurity of clay. It occurs as earthy grains, as

metallic scales or as a superficial coating on other mineral grains found in the clay. It dissolves quietly in muriatic acid. Iron may also occur in the clay as a constituent element of many silicates, and indeed the effect which it produces may be caused not so much by the actual amount of iron oxide which is present, but by the condition which it is in.

Iron oxide is very apt to form concretions in the clay, and these concretions which generally have a shell-like structure, vary in diameter commonly from a fraction of an inch to several inches. Siderite, the carbonate of iron, which is also to be found in many clays, likewise forms concretions or opaque rounded masses, which effervesce on the addition of warm muriatic acid. The exterior of these siderite concretions is not unfrequently altered to limonite, the brown or yellowish hydrated oxide of iron. Such concretions are hard and rock-like in their nature, and either have to be separated by screening the clay before using, or crushed by passing the clay between rolls.

PYRITE.

This mineral is a compound of iron and sulphur, and the grains of it are easily recognized by their metallic lustre and their yellow color. It is a very common constituent of many fire clays, and occurs either in the form of small grains or concretionary masses of yellow crystals. Its bright metallic surface will serve to distinguish it from limonite which has a dirty appearance.

DOLOMITE.

This is a double carbonate of lime and magnesia, and may occur in a clay in the same form as calcite, and the effect of it is practically the same.

METHODS EMPLOYED IN MAKING CLAY ANALYSES.*

The following brief statement of the methods employed in making the analyses of clays for this report has been prepared by Dr. Charles Baskerville, by whom the analyses were made:

Moisture—Two grams are heated in a platinum crucible at 100° C. until they show a constant weight. The loss is reported as moisture.

Loss on Ignition (combined water, and sometimes organic matter, etc.)—The crucible and clay are heated with a blast lamp until there is no further loss in weight.

Alkalies—This same portion of clay, which has been used for determining moisture and loss, is treated with concentrated sulphuric and hydrofluoric acids until it is completely decomposed. The acids are evaporated off by heating upon the sand-bath. The cooled crucible is washed out with boiling water to which several drops of hydrochloric acid have been added. The solution after being made up to about five hundred cubic centimetres is boiled, one-half gram ammonia oxalate added and made alkaline with ammonium hydroxide; the boiling is continued until but a faint odor of ammonia remains. The precipitate is allowed to settle and is separated from the liquid by filtering and washed three times with boiling water. The filtrate is evaporated to dryness and ignited to drive off ammonia salts. The residue is treated with five cubic centimetres of boiling water, two or three cubic centimetres of saturated ammonium carbonate solution are added and the whole is filtered

*Reprinted from Bulletin No. 13, North Carolina Geological Survey, 1897.

into a weighed crucible or dish. The precipitate is washed three or four times with boiling water and the filtrate evaporated to dryness. Five drops of sulphuric acid are added to the residue, and then the crucible or dish is brought to a hot heat, cooled in a desicator, and the alkalies are weighed as a sulphate.

To separate the alkalies, the sulphates are dissolved in hot water, acidified with hydrochloric acid, sufficient platinum chloride added to convert both sodium and potassum salts into double chlorides; the liquid is evaporated to a syrup upon a water-bath, eight per cent. alchohol added, and filtered through a Gooch crucible or upon a tared filter paper. The precipitate is thoroughly washed with eighty per cent. alcohol, dried at 100° C. and weighed; the potassium oxide is calculated from the double chloride of potassium and platinum.

When magnesium was present to as much as one-half of one per cent., the magnesium hydroxide was precipitated with barium hydroxide solution and the barium in turn removed by ammonium carbonate. When the amount of magnesium was less than the amount named, this portion of the ordinary process was not regarded as necessary.

Silica—Two grams of clay are mixed with ten grams of sodium carbonate and one-half gram of potassium nitrate and brought to a calm fusion in a platinum crucible over the blast lamp. The melt removed from the crucible is treated with an excess of hydrochloric acid and evaporated in a casserole to dryness upon a water-bath, and heated in an air-bath at 110° C. until all the hydrochloric acid is driven off. Dilute hydrochloric acid is added to the casserole now, and the solution brought to boiling and rapidly filtered.

The silica is washed thoroughly with boiling water and then ignited in a platinum crucible, weighed, and moistened with concentrated sulphuric acid. Hydroflouoric acid is cautiously added until all the silica has disappeared. The solution is evaporated to dryness upon a sand-bath, ignited and weighed. The difference in weight is silica.

Iron Sesquioxide—The filtrate from the silica is divided into equal portions. To one portion in a reducing flask is added metallic zinc and sulphuric acid. After reduction and filtration to free the liquid from undissolved zinc and carbon, the iron is determined by titration with a standard solution of potassium permanganate.

Aluminium Oxide—To the second portion, which must be brought to boiling, ammonium hydroxide is added in slight excess, the boiling continued from two to five minuts, the precipitate allowed to settle and then caught upon the filter, all of the chlorides being washed out with boiling water. The precipitate is ignited and weighted as a mixture of aluminium oxide and iron sesquioxide. The amount of iron sesquioxide already found is taken from this and the remainder reported as alumina.

Calcium Oxide—The filtrate from the precipitate of iron and aluminium hydroxides is concentrated to about two hundred cubic centimetres, and the calcium precipitated in a hot solution by adding one gram of ammonium oxalate. The precipitate is allowed to settle during twelve hours, filtered and washed with hot water, ignited and weighed as calcium oxide. When the calcium is present in notable amounts, the oxide is converted into the sulphate and weighed as such.

Magnesium Oxide—The filtrate from the calcium

oxalate precipitate is concentrated to about one hundred cubic centimetres, cooled, and the magnesium precipitated by means of hydrogen disodium phosphate in a strongly alkaline solution, made so by adding ten cubic centimetres of ammonium hydroxide (0.90 sp. gr.). The magnesium ammonium phosphate, after standing over night, is caught upon an ashless filter, washed with water containing at least five per cent. ammonium hydroxide, burned and weighed as magnesium pyrophosphate.

The *insoluble residue* is determined by digesting two grams of clay with twenty cubic centiments of dilute sulphuric acid for six or eight hours on a sand-bath, the excess of acid being finally driven off. One cubic centimetre of concentrated hydrochloride acid is now added and boiling water. The insoluble portion is filtered off, and after being thoroughly washed with boiling water is digested in fifteen cubic centimetres of boiling sodium hydroxide of ten per cent. strenth. Twenty-five cubic centimetres of hot water are added and the solution filtered through the same filter paper, the residue being washed five or six times with boiling water. The residue is now treated with hydrochloric acid in the same manner and washed upon the filter paper, and free from hydrochloric acid, is burned and weighed as insoluble residue.

A portion of this is treated as the original clay for silica, aluminium oxide and iron oxide. Another portion is used for the determination of the alkalies in the insoluble residue.

Titanic Oxide—One-half gram of clay is fused with five grams potassium bisulphate and one gram sodium fluoride in a spacious platinum crucible. The melt is dissolved in five per cent. sulphuric acid. Hydrogen dioxide is added to an aliquot part and the tint com-

pared with that obtained from a standard of titanium sulphate.

Sulphur (total present)—The sulphur is determined by fusing one-half gram of clay with a mixture of sodium carbonate, five parts, and potassium nitrate, one part. The melt is brought into solution with hydrochloric acid. The silica is separated by evaporation, heating, resolution, and subsequent filtration. Hydrochloric acid is added to the filtrate to at least five per cent. and the sulphuric acid is precipitated by adding barium chloride in sufficient excess, all solutions being boiling hot. The barium sulphate is filtered off and washed with hot water, burned and weighed as such.

Ferrous Oxide—is determined by fusing one-half gram of clay with five grams sodium carbonate, the clay being well covered with the carbonate, the top being upon the crucible. The melt is dissolved in a mixture of dilute hydrochloric and sulphuric acids in an atmosphere of carbon dioxide. The ferrous iron is determined at once by titration with a standard potassium permanganate solution.

The *rational analysis* is made from the results obtained by the chemical analysis in the following way: The alumina found in the portion insoluble in sulphuric acid and sodium hydroxide is multiplied by 3.51. This factor has been found to represent the average ratio between alumina and silica in orthoclase feldspar; therefore the product just obtained would represent the amount of silica that would be present in undecomposed feldspar. The sum of this silica with the alumina, ferric oxide and alkalies equals the "feldspathic detritus." The difference between silica as calculated for feldspar and the total silica in the insoluble portion represents the "quartz" or "free

sand." The difference between that portion of the sample insoluble in sulphuric acid and sodium hydroxide and the total represents the "clay substance." The method of analysis used to detrmine the mineralogical character of the clay is called the *rational* method, and when carried out in its simplest form, determines the amount of clay substance or kaolinite, quartz, and feldspar present 'n the clay. If carried out more completely, it enables us to calculate the amount of calcite or limestone (calcium carbonate)' iron oxide and even mica in the clay.

THE RATIONAL ANALYSIS OF CLAY.

The rational analysis of clay consists in resolving the clay into its mineralogical elements, thus giving a clue to its physical as well as its chemical properties. It is often utilized by manufacturers of porcelain and other high grades of ware as a guide in the compounding of their mixtures.

The ordinary quantitative or ultimate analysis regards the clay as a mixture of oxide of the elements, although they may be present in entirely different combinations, such as silicates, carbonates, hydrates, sulphates, etc. This condition of combination is important for it makes a difference in the behavior of the clay. Thus for instance, if silica is present in the form of quartz it will decrease the shrinkage and also increase the refractoriness up to a certain point, but if present as a component element of feldspar it serves as a flux and also increases the plasticity somewhat.

It is not intended though that the rational analysis

shall fully supplant the ultimate one for each serves its own purpose.

The ultimate analysis may be used to supply information on the following points.

1. The purity of the clay, by showing the proportions of silica, alumina, combined water and fluxing impurities.

2. From the ultimate analysis we can form a general idea regarding the refractoriness of the clay, for, other things being equal the greater the total sum of the fluxing impurities, the more fusible the clay.

3. The color to which the clay burns may also be judged approximately for the greater the amount of iron in the clay the deeper red will it burn, provided the iron oxide is evenly distributed, and there is not an excess of lime in the clay. If the proportion of iron to lime is as 1; 3, then a buff product results, provided the clay is only heated to incipient fusion or vitrification. The above conditions will be affected by a reducing atmosphere in burning or of sulphur in the fire gases.

4. Clays with a large amount of combined water sometimes exhibit a tendency to crack in burning. This combined water would be shown in the ultimate analysis.

5. A large excess of silica would indicate a sandy clay.

The connection between refractoriness and chemical composition may be illustrated by the following analysis.

The following analyses indicate this fact:

	1	2	3
	Per cent.	Per cent.	Per cent
SiO_2	47.20	69.50	54.90
Al_2O_3	36.50	13.00	18.03
Fe_2O_3	2.56	6.40	6.03
CaO	tr.	.25	2.88
MgO	tr.	tr.	1.10
Alkalies		tr.	3.40
H_2O	13.35	6.70	6.90
Moisture	.50	3.40	3.17
Total fluxes	2.56	6.65	13.41
	DEG. F.	DEG. F.	DEG. F.
Viscosity or fusion point.	Above 2700	2300	1900

1. Chalk Bluff, Marion Co., Ala., *U. S. Geol. Surv.* 18th *Ann. Rep.*, Part V. (continued), p. 1128.
2. Fernbank, Lamar Co., Ala. *Ibid.*
3. Norborne, Mo. *Mo. Geol. Surv.*, XI. *Ann. Rep.*

This is practically the full extent to which the ultimate analysis can be used; and there still remain to be explained a number of physical facts concerning any clay which happens to be under consideration.

It frequently happens that two clays approach each other quite closely in their ultimate composition, and still exhibit an entirely different behavior when burned. The explanation which most quickly suggests itself is, that the elements present in the two clays are differently combined. Some method of resolving the clay into its mineral components, so as to indicate the condition in which the elements are present is therefore practically needed.

As kaolinite results from the decomposition of feldspar, the kaolin is quite sure to contain some undecomposed feldspar, and also some quartz, and (in smaller amounts) mica, since the two latter minerals are common associates of the feldspar.

If, now, we know the amount of feldspar, quartz and kaolinite or clay-substance in the kaolin, and the effect of these individual minerals, we can form a far

better opinion of the probable behavior of the clay in burning.

When mica is present, it is dissolved out with the kaolinite and reckoned in as clay-substance, but it is rarely present in large amounts, and may perhaps alter the character of the clay-substance but little, for finely ground white mica possesses plasticity, and can be formed and dried without cracking. It is more refractory than feldspar, and holds its form up to 1400° C.*

In the following table are given the ultimate and rational analyses of a number of kaolins, which show how a constancy of ultimate composition may be accompanied by variations in the rational analysis:

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* G. Vogt, *Chem. News*, 1890, p. 315.

TABLE I.—*Ultimate and Rational Analyses of Clays.*

	1	2	3	4	5	6	7	8	9	10	11	12
	ULTIMATE ANALYSIS.											
SiO_2	62.40	62.52	63.17	64.87	63.07	54.51	53.10	47.60	46.61	58.39	46.82	57.08
Al_2O_3	26.51	25.57	25.09	23.83	24.67	31.41	33.06	34.00	36·47	27.52	38.49	29.94
Fe_2O_3	1.14	.92	.64	.83	.59	.68	1.18	1.30	2.81	.36	1.09	.65
CaO	.57	.65	.35	....	....	.04	.38	Tr.	·14	1.52	....	....
MgO	·01	.10	.26	.50	.40	.43	.08	.50	....	.41	Tr.	.49
Alkalies	.98	1.04	.80	1.39	4.25	.55	.83	3.00	1.44	4.29	1.40	2 26
Loss by ignition	8.80	9.27	9.70	8.36	7.00	12.37	11.32	13.60	12.80	7.19	12,86	9.87
	100.41	100.07	100.01	99.78	99.98	99.99	99.95	100.00	100.27	99.68	100.66	100.29
	RATIONAL ANALYSIS.											
Clay substance	66.33	72.05	67.82	63.77	54.92	83.04	83.39	88.34	96.08	55.88	96.55	74.09
Quartz	15.61	27.78	30.93	35.50	23.52	16.28	14.99	8.95	1.93	5.95	2.30	17.21
Felspar	18.91	.10	1.25	.73	21.56	.28	1.57	2.73	1.99	38.17	1.15	8.70
	100.85	99.93	100 00	100.00	100.00	100.0	99.95	100.02	100.00	100.00	100.00	100.00

1. Crude kaolin, Springer mine, Webster, N. C. *Bull, N. C. Geol. Surv.*, on "Clays of North Carolina."
2. Slip-clay from Ruhle's mine, Lothian, Saxony. *Thon.-Ind.-Zeit.*, 1892, p. 1031.
3. Slip-clay from Kaschkau, Germany, *Ibid.*
4. Kaolin from Sennewitz, Saxony. *Notizblatt*, 1876,
5. Porcelain-clay mixture, *Ibid.*
6. White earthenware clay, Lothain, Saxony, *Seger's Ges. Schr.*, p.887.
7. Kaolin (unwashed), West Mills, N. C. *Bull, N. C. Geol. Surv.*, on "Clays of North Carolina."
8. White earthenware clay, Wiesau, Germany. *Thon.-Ind.-Zeit.*, 1894, p. 858.
9. Fire-clay, Bautzen, Germany. *Ibid.*, 1894, p. 842.
10. Kaolin, Limoges, France. *Seger's Ges. Schr.*, p. 552.
11. Kaolin, Zettlitz, Bohemia. *Ibid.*, p. 50.
12. Kaolin, Lettin, Saxony. *Ibid.*, p. 50.

From this table a number of interesting conclusions may be drawn. Columns 1 and 2 represent two clays which agree very closely in their ultimate composition; but in the rational analysis there is a difference of 6 per cent. in the clay-substance, 12 per cent. in quartz, and nearly 19 per cent. in the feldspar. Nos. 3 and 5 and 10 and 12 also illustrate this point.

In Nos. 6 and 7, one a German, and the other a North Carolina kaolin, the ultimate analyses are very closely alike, and the rational analyses also agree very well. This is frequently the case when the clay-substance is very high, between 96 and 100 per cent., as in Nos. 9 and 11.

A third case would be presented if the rational analyses agreed, but the ultimates did not. Such instances, however, seem to be much less common.

The practical value of the rational analysis bears chiefly upon those branches of the clay-working industry, such as manufacture of porcelain, white earthenware, fire-brick and glasspots, which use materials with comparatively few fusible impurities (iron, lime, magnesia).

There is much concerning clays which sitll remains unexplained, but it seems probable that, other things being equal, two clays having the same *rational* composition will behave alike.

We can illustrate this point by the follownig tests made on washed kaolins from the vicinity of Sennewitz, near Halle, Germany. From the figures given below, it will be noticed that in the case of Nos. 1 and 2 there is a close agreement in the shrinkage, which amounted to about 10 per cent. when the clay was heated up to the temperature of a hard-porceclain kiln. In Nos. 3 and 4 the shrinkage is very nearly the same, but greater than in Nos. 1 and 2, because the

rational composition has changed, there being a marked increase in the amount of feldspar.

If there hed been much difference in the size of the clay-particles of Nos. 3 and 4 or Nos. 1 and 2, the shrinkage in each case would probably have been different.

TABLE II.—*Rational Analysis and Shrinkage of Clays.*

Feldspar. Per cent.	Quartz. Per cent.	Clay-Substance. Per cent.	Fe_2O_3 Per cent.	Shrinkage in Hard Porcelain Fire Per cent
1.59	33.86	64.55	0.75	10.20
1.21	33.39	65.40	0.73	10.10
8.64	31.69	59.68	0.30	12.90
8.25	35.15	56.60	0.30	12.00

The degree of fineness of the clay-particles, and perhaps their shape also, probably exert more influence on the shrinkage than has been imagined, but just how far this makes itself felt is still undetermined.

As an illustration of the practical use of the rational analysis we may take the following:

Suppose that we are using for the manufacture of porcelain or fire-brick a kaolin which has 67.82 per cent. of clay-substance, 30.93 of quartz, and 1.25 of feldspar, and that to 100 parts of this is added 50 parts of feldspar. This would give us a mixture of 45.21 per cent. of clay substance, 20.62 of quartz, and 34.17 of feldspar.

If now for the clay we had been using, we substituted one with 66.33 per cent. of clay-substance, 15.61 of quartz, and 18.91 of feldspar, and made no other changes, the mixture would then contain 44.22 per cent. of clay-substance, 10.41 of quartz and 45.98 of feldspar.

This last mixture shows such an increase in feldspar that it must give much greater shrinkage and fusibil-

ity; but knowing the rational analysis of the new clay, it would be easy to add quartz or feldspar so as to bring the mixture back to its normal composition.

The application of the method of rational analysis to impure clays is not quite as satisfactory, but at the same time not as necessary. In the treatment, the iron, if present as oxide, and lime or magnesia, if carbanotes, are dissolved out with the clay-substance. The silicate minerals are grouped with the feldspar, and the clay thus becomes divided into clay-substance (kaolinite, ferric oxide, lime and magnesia carbonates), feldspar or feldspathic detritus; and quartz. If the percentage of ferric oxide and carbonates is high, it is necessary to determine them separately in the ultimate analysis.

In making a rational analysis, the clay is treated with strong sulphuric acid, which decomposes the kaolin into sulphate of alumina and hydrous silica. The former is soluble in water, while the latter is removed with caustic soda, and we get an insoluble residue consisting of quartz and feldspar. In this residue the alumina is determined and the feldspar calculated.

Another way of conducting the rational analysis, and one which is chiefly applicable when the clay contains other minerals besides the kaolin, quartz and feldspar, such as carbonate of lime, ferric oxide, or mica, consists in analysing the insoluble residue and calculating the mineral percentages from this.

THE CLASSIFICATION OF CLAYS.

As it is possible to find every gradation from the purest to the most impure clays any classification that is attempted, will necessarily be more or less unsatisfactory. It is of course possible primarily to make

two great divisons i. e. residual and sedimentary, and to these might perhaps be added a third class of clays, namely, those formed by chemical precipitation. Under each of the first two classes, it would be possible again to find every gradation from pure to impure.

It is not possible to make any classification based upon the practical applications of the materials, for some clays are used for as many as four to five different purposes, and it is probable that some classification which simply recognizes four or five important groups is probably the most satisfactory and the least confusing. Hill makes the following divisions:*

China clays.

Plastic, ball, pottery clays.

Brick clays.

Refractory or fire clays.

He furthermore makes another table based on the origin of the clay as found in the United States:

I—WHITE BURNING CLAYS.

1. Rock or residual kaolin.
2. Indianite or Indiana kaolin.
3. Florida or sedimentary kaolins.
4. White burning plastic clays.

II—COLOR BURNING CLAYS.

Mixed clays—

1. Brick clays, (Siliceous).
2. Marly clays, (Calcareous).
3. Pink clays, (Ferruginous).
2. Cement clays, (Silico-calcareous).
5. Alum clays.

Altered clays (shale and slate).

*U. S. Geol. Survey, Mineral Resources, 1893.

A classification which has been made by Seger, the great German Ceramic Chemist, gives:

1. *Yellow burning,* containing lime and iron.
2. *Red burning,* non-aluminous, ferruginous clays, which are free from lime.
3. *White and yellow burning.* These clays are low both in lime and iron.
4. *White burning,* low in iron and high in alumina.

THE MINING AND PREPARATION OF CLAYS.

RPOSPECTING FOR CLAYS.

Clay deposits are best seen in those regions where rivers and brooks have cut gullies and ravines, the clay showing on the sides of the cut. In such locations the thickness of the deposit and variation in its character vertically are well shown. Similar sections are to be loooked for along railroads. As the beds are apt to wash down it is necessary to clean the surface of the cut before taking any sample for testing, and even then great care must be observed to insure the sample being an average one.

Apart from cuts the presence of clay can often be determined by the character of the vegetation, the nature of the soil, or upturned tree roots.

The outcropping of clay in a ravine should not be depended on alone, but in addition borings should be made to determined the depth and extetnt of the deposit, and persistance of the different layers if there is a variation in them.

Shale often forms cliffs or steep slopes, at the base of which there may be a talus of partly weathered fragments and soft clay; in fact the outcrop of a shale deposit may be covered by the clay into which it has

slaked under the influence of weathering. In some localities this mellowed outcrop may be only a few feet thick, but in many it is of sufficient volume to supply a small brick yard, without the necessity of attacking the fresh shale beneath.

MINING OF CLAYS*.

Clays, when soft and plastic, are mostly dug with pick and shovel, loaded on wheel-barrows, carts or cars and hauled to the works. If the deposit is broad and shallow the clay is usually dug at any convenient point; often any overlying sand or other useless material has been first removed and used for filling in or some other purpose.

If the bank is located on the hillside, and has considerable height, it is worked out in broad steps, the object of this being to prevent the bank from sliding in wet weather.

When the bank is near the works, wheel-barrows or carts can be used to haul the clay, but far distances, over 600 feet, it pays to lay tracks and use cars, hauled either by horse or steam power.

Underground methods of mining are only used in case the amount of overlying material is very great. It is chiefly used for shale deposits.

Steam shovels are employed for sandy clays or soft shales at some localities in the Uuited States, but most shales are mined by blasting, and the fragments thus ioosened are sent to the works.

Where the clay is rough, and the face of the bank 12 or 15 feet high, a plan often followed is to undermine it by picking at the base, and then inserting large wooden wedges at the top. This brings down

*This does not include the mining of kaolin, which is treated separately.

a large mass at once, the fall serving to break it up. While effective, this method is often attended with danger.

MINING OF KAOLIN.

Kaolin is usually sufficiently soft in nature to be mined by means of the pick and shovel. In some portions of the beds near Valley Head streaks of *halloysite* are found in the clay, which are quite hard, but they are of such a limited extent as not to cause much extra trouble. If the deposit is deep, narrow, or interbedded with other formations which are too thick to be removed by stripping, or if again the kaolin does not run regular in its composition, it is often advisable to follow the better portions of the bed, or the narrow vein if it is such, by means of shaft, levels, or slopes. These sometimes have to be timbered, at other times, as at Valley Head, they do not.

In the case of deposits which are large and broad, it is most economical to operate them as quarry workings or open pits, digging out the material and loading it on the cars or wheel-barrows which convey it to the washing plant. If a pit is large and broad the sides, instead of being dug out vertically, should be left in benches to prevent the washing down of the bank.

In North Carolina, where most of the kaolin deposits are vein formations whose depth is comparatively great as compared with their width, the method adopted is to sink a circular pit in the kaolin about 25 feet in diameter. As the pit proceeds in depth it is lined with crib work of wood, and this lining is extended to the full depth of the pit, which varies from 50 to 100 or even 120 feet. When the bottom of the

kaolin has been reached the filling in of the pit is begun, the crib work removed from the bottom upward as the filling proceeds. If there is any overburden this is used for filling in the pit, and as soon as pit is worked out a new one can be sunk in the same manner right next to it. In this way the whole vein is worked out, and if the deposit is large, several pits may be sunk at the same time to increase the output of the mine.*

Hydraulic mining has been tried with some success in some very sandy loose-grained kaolins, but it would not work in any of the deposits in Alabama, which the writer has thus far examined. The method to state it briefly, consists in washing the clay down into the bottom of the pit whence it is sucked up by means of a pump and discharged into washing trough from the conveying pipe, it being sometimes necessary to have a scraper to stir or loosen up the clay in order to permit its being drawn up more easily. This is a cheap and rapid methed where it can be employed, but most kaolins are too dense and not sandy enough to allow of its being used.

THE WASHING OF KAOLINS.

As has already been stated, most kaolins have to be washed before shipment, and one of two methods may be employed, i. e. washing in tanks or troughing. With the first method or that of washing in tanks, the kaolin is thrown into large circular tubs filled with water, in which it is stirred up by means of revolving arms and the clay lumps thereby disintegrated. By this treatment the fine kaolinite particles as well as very fine grains of mica, feldspar, and quartz remain

*H. Ries, Clay Deposits and Clay Industry in North Carol'na Bulletin No. 13, N. C. Geol. Surv., p. 54.

suspended in the liquid while the coarser grains settle on the bottom of the tank. The water with the suspended clay is then drawn off to the settling tanks.

A modification of this consists in the use of a large cylinder closed at both ends and set in a horizontal position; through this cylinder passes an axis with iron arms, the revolution of the latter serving to break up the clay, which is discharged through a hopper at the top. A current of water passes through the cylinder and carries the fine clay particles with it while the coarse ones are left behind in the machine. The speed of the current has to be regulated by experiment, for if too much water is used coarse material will be washed out of the cylinder, and conversely, if the current is too slow the clay will not yield a sufficient percentage of washed product. One objection to this apparatus is that it has to be stopped from time to time to remove the coarse sand from the machine.

The method most commonly used at the present day for washing kaolin, is by troughing and its general detail is as follows:

As the kaolin comes from the mine it is generally discharged into a log washer, which consists of a semicylindrical trough in which there revolves a horizontal axis, bearing short arms. The action of these arms breaks up the kaolin more or less thoroughly, depending on its density, and facilitates the subsequent washing. The stream of water directed into the log washer sweeps the kaolin and most of the sand into the washing trough, which is about 15 inches wide and 12 inches deep. It may be wider and deeper if the kaolin is very sandy; in fact it should be. The troughing is about 700 feet long, and to utilize the space thoroughly, it is broken up into sections, 50 feet to each is a

good length, these being arranged paralleled, and connected at the ends, so that the water, with suspended clay, follows a zigzag course.

This troughing has a slight pitch which is commonly about one inch in twenty feet, but the amount of pitch depends upon the kaolin, and whether the sand which it contains is fine or coarse. If the kaolin is very fine, and settles slowly, the pitch need not be so great and vice versa. A large quantity of very coarse sand in the kaolin is a nuisance as it clogs up the log washer, and upper end of the trough more quickly and causes so much more labor to keep them clean. As it is, considerable sand settles there, and, to keep the trough clear, sand wheels are used. These are wooden wheels bearing a number of iron scoops on their periphery, as the wheels revolve these scoops catch up a portion of the sand which has settled in the trough, and as each scoop reaches the upper limit of its turn on the wheel, it, by its inverted position, drops the sand outside of the trough. These sand wheels are an aid, but it is often necessary, in addition, to keep a man shoveling the sand from the trough.

If the sand is finer it is not dropped so quickly, but is distributed more evenly along the trough, and does not clog it up so fast.

The zigzag arrangement of the troughing has been objected to by some, as it produces irregularities in the current causing the sand to bank up in the corners at the bends, and also at certain points along the sides of the troughing.*

The effect of this is to narrow the channel, and consequently to increase the velocity of the current, thereby causing the fine sand to be carried still further to-

*E. Hotop, Thonindustrie Zeitung, 1893.

ward the settling tank. This difficulty, which is not often a serious one, has been obviated either by having the troughing longer or by allowing the water and suspended clay, as they come from the log washer, to pass through a section of straight trough, and from this into another one, of the same depth but five or six times the width, and divided by several longitudinal partitions. The water and the clay then pass into a third section, twice as wide as the second, and divided by twice the number of longitudinal divisions.

By this means the water moves only in a straight course, but as it is being continually spread out over a wider space it flows with an ever decreasing velocity.

By the time the water has reached the end of the troughing, nearly all of the coarse grains have been dropped and the water is ready to be led into the settling vats, but as a further and necessary precaution it is discharged on to a screen of one hundred meshes to the linear inch, the object of this being to remove any coarse particles that might possibly remain, and also to eliminate sticks and other bits of floating dirt that are sure to find their way in.

Two kinds of screens can be used, (1) stationary, and (2) revolving.

The stationary screen is simply a frame with a copper cloth and set at a slight angle. The water and suspended kaolin fall on the screen, and pass through. A slight improvement is to have two or three screens which overlap each other so that whatever does not get through the first will fall on the second. If the vegetable matter and sticks are allowed to accumulate, they stop up the screen, and prevent the kaolin from running through, consequently the stationary screens have to be closely watched.

The revolving screens are far better for they are

self cleaning. Such screens are barrel shaped, and the water, with the kaolin in suspension, is discharged into the interior and passes outward through the screen cloth. As the screen revolves, the dirt caught is carried upwards and finally drops; but instead of falling down upon the other side of the screen, it falls upon a board, which diverts it out upon the ground.

The settling tanks, into which the kaolin and the water are discharged, may be and often are about eight feet wide by four feet deep, and fifty or more feet long. As soon as one is filled the water is diverted into another.

The larger a tank, the longer will it take to fill it, and allow the kaolin to settle, and delays due to this cause them to be expensive, especially when the market takes the output of washed kaolin as soon as it is ready.

Small tanks have the advantage of permitting the slip to dry more quickly, especially when the layer of clay is not very thick, and furthermore a small pit also takes less time to fill and empty, but one disadvantage urged against a number of small tanks is that a thorougly average product is not obtained owing to the thin layer of settlings and the small amount in each. In addition to this a series of small tanks requires considerable room.

The advantages claimed for large tanks are that the clay can be discharged into any one for a considrable period, and, if the clay deposit varies in character, the different grades get into one tank and a better average is thereby obtained.

If the kaolin settles too slowly, alum is sometimes added to the water to hasten the deposition. When the kaolin is settled, most of the clear water is drawn off, and the cream like mass of kaolin and water in the

bottom of the vat is drawn off by slip pumps and forced by these into the presses.

The presses consist simply of flat iron or wooden frames between which are flat canvas bags. These bags are connected by nipples with a supply tube from the slip pumps, and by means of the pressure from the pumps nearly all of the water is forced out of the kaolin and through the canvass.

When all of the water possible, is squeezed out the press is opened and the sheets of semi-dry kaolin are taken out. It is then dried either on racks in the open air or in a heated room.

As for every ton of crude kaolin usually only about two-fifths or one-fourth of a ton of washed kaolin is obtained, it is desirable to have the washing plant at the mines, for it avoids the hauling of 60 to 70 per cent. of useless sand which has to be washed out before the kaolin can be used or even placed on the market.

II.

GEOLOGICAL RELATIONS OF THE CLAYS OF ALABAMA,

BY EUGENE A. SMITH, PH. D.

The basis of all clays is kaolinite, the hydrated silicate of alumina resulting from the chemical decomposition of alumina bearing minerals which occur as essential constituents of igneous rocks. In this decomposition, as Dr. Ries has shown, the soluble constituents are leached out while the kaolinite remains behind as an insoluble residuum, more or less mixed with the other insoluble matters of the original minerals.

In this form the clay might be called a chemical clay, since it is the direct result of a chemical decomposition, having undergone no further modification by being taken up, transported and redeposited.

There is another form of residual clay which may be distinguished from the above, and that is the clay resulting from the decomposition of impure limestone. Naturally this variety is usually less free from foreign matters than the other.

These residual clays taken up and redeposited by running waters are incorporated in the stratified deposits of any later age.

The clay deposits of the different geological formations of Alabama have each its well marked peculiarities, and the geological formations are clearly de-

fined, so that an account of the geological relations of these clays becomes a guide at once to the several varieties, and to their geographical distribution.

ARCHAEAN AND ALGONKIAN.

These two formations include in Alabama all the crystalline rocks of both igneous and sedimentary origin. It is generally acknowledged that kaolinite, which is the basis of all clays, has its origin in the decomposition of the minerals composing the igneous rocks, the chief kaolinite producing mineral being feldspar. It is. therefore, in the area of our crystalline or metamorphic rocks that we are to look for the original deposits of kaolinite. More especially, it is the granites, the *pegmatites or graphic granites,* that occur the largest proportion of feldspar, and consequently yield the largest proportion of kaolinite, and of the granites, the*pegmatites* or *graphic granites,* occurring in veins which traverse the other crystalline rock, are by far the most important in this respect.

The clays occurring in this form have been spoken of by Dr. Ries as vein clays, and they are, as a rule, very slightly plastic, for the reason that they have not been subjected to the comminuting processes necessary to develop the highest degree of plasticity.

A belt of mica schists with frequent veins of pegmatite, extends from Cleburne county and adjacent parts of Randolph, through Clay and Coosa into Chilton county, and in numerous places, the decay of the granite veins has given rise to the formation of deposits of kaolinite. The other two constituents of these granites, viz., quartz and mica, occur like the feldspars in large masses, and thus the places which produce mica in large sheets are at the same time the

places where the kaolinite is to be found. Below a certain depth from the surface the feldspar of these granitic veins has escaped the action of the atmosphere, and is in its original form, while nearer the surface it has generally been converted into kaolinite. It is evident that in all these primary or original deposits the kaolinites mixed with the other and less destructible constituents of the granite, viz., the quartz and the mica, and by consequence all the kaolinite from such original deposits must be washed to free it from these substances. When the granite or granitic rock contains comparatively little of iron-bearing minerals the resulting kaolinite will be correspondingly free from iron stain and of pure white color, and thus suitable for the manufacture of the finer grades of stone ware or china.

All the important deposits of this kind are, at the present time, at a distance from any railroad, and none of them have been developed in a commercial way. We have at hand very few analyses and tests made of these kaolinites. A material of this kind from near Louina in Randolph county was analyzed many years ago by Dr. Mallett for Prof. Tuomey, with the following result:

Analysis of Kaolinite from Louina, Randolph Co.

Silica	37.29
Alumina	31.92
Ferric Oxide	trace
Potash, Lime and Magnesia	0.72
Water	15.09
Undecomposed Mineral	14.28

Prof. Tuomey remarks upon the absence of iron in this kaolinite as most favorable to its use in making fine porcelain ware, and he predicts that when Randolph county has communication by railroad with the

outside world, the occurrence of porcelain clay in the county will become a matter of economic importance.

These pegmatite veins with their mica and kaolinite, are very numerous in the upper half of Randolph county, and also in the adjacent parts of Cleburne and Clay, and test pits have been sunk in hundreds of places to show up both the kaolinite and the mica. Dr. Caldwell of the Elyton Land Company, had this kaolinite thoroughly tested both as to its suitability for the manufacture of porcelain ware and as to its refractory character. The pottery ware made from it came in competition with the best pottery wares in America and took a prize at the. Art Institute Fair in Philadelphia, in December, 1890. Brick made from it also was subjected to the highest temperature of the furance and was declared practically infusible. These deposits lie near Milner, Pinetucky, Micaville, in Randolph, and near Stone Hill, Mr. Jas. Denman's and other places in Cleburne. The same belt extends southwestward through Clay and Coosa into Chilton, and has been tested at various places along this line.

In this region of the crystalline rocks, one may everywhere observe the gradual transition from the solid rock through decayed schists into complete soil, which is generally a clayey loam, more or less stained wih iron. A reddish clay is thus seen to be a part of the residual matters left by the general decay of the rocks of this section, but this clay is, as a rule, so much mixed with quartz, mica, fragments of undecomposed rock, that it can serve very seldom for anything more than material for the manufacture of building brick. Residual clays of this character are of universal occurrence throughout the region of our crystalline rocks.

It is not difficult to understand how under certain

conditions, the finer portions of these residual clays may be taken in suspension in running waters and redeposited at greater or less distances from their place of origin in depressions, or along slopes. In this way are often formed secondary deposits of pretty fair plastic clays, sometimes mixed with sand in proportion to serve well as material for good building brick. An illustration of this may be cited near Wedowee in Randolph county, and there are many instances where the residual clays of the country as well as these redeposited masses are utilized both for the manufacture of buildings brick of excellent quality, and for pottery purposes.

CAMBRIAN AND SILURIAN FORMATIONS.

In these formations, the clay deposits are either the residual clays left from the decomposition generally of the great limestone formations of the Cambrian and Silurian, or concentrations of these residual clays by redeposition in sink holes, ponds, and depressions; or the accumulation through sedimentary action ,in the depressions of these later formations, of the chemical or vein clays of the Archaean.

The two great limestones, above mentioned, are rarely pure but are mixed with chert or other form of siliceous matters, with iron, and with clay. Upon their decay under the action of the atmospheric agencies, these insoluble matters are left in the form generally of reddish loam or clay capped with cherty fragments, and impregnated with iron.

Such residual clays are extensively used in all our valley regions for the manufacture of ordinary building brick, for which they are very well adapted, the

brick being very durable, but not very sightly, since they are likely to be spotted where the clay contains more iron than the average. Occasionally, however, we find as result of subsequent rearrangement by leaching, concretionary action, or the like, these residual matters differentiated from each other in a most remarkable way, so that beds of nearly pure white clay lie alongside of beds of brown iron ore, itself remarkably free from either clay or chert. The most notable of such instances is at Rock Run where the bed of white kaolin, analysis of which is given in the body of this report, No. A. S., forms one of the walls of a bank of limonite which has for years furnished ore to the furance. In close juxtaposition to the ore and kaolin, here mentioned, is one of the beds of bauxite for which this region is well known. Kaolin beds of this residual nature are known in many other parts of the State, resting upon the Cambrian and Silurian limestones. Near Jacksonville, in Calhoun county, at Tampa in the same county, and in numerous other localities of similar nature, are limited beds of kaolin, none of which, however, have as yet been developed or worked.

The following clays described below may be assigned to these formations; the china clays, No. 190, from near Gadsen and No. 205 from Kymulga; the fire clays, No. 191 from Peaceburg in Calhoun county and No. 127 from Oxanna in the same county; the stoneware clays, No. 204 from Blount county and No. 192 from near Rock Run.

In most of the large limonite banks of the valley regions, these deposits of pure clay occur, usually known as clay horses, some of them are undoubtedly of sufficient extent to be of commercial value. Many

references to these may be found in the Report on the Valley Regions.

While none of these clay deposits have as yet found a market, it may be well for the sake of completeness to give a few details concerning such as have been recorded. The references to the pages of the report on the Valley Regions, Part II, are also added.

In connection with beds of limonite in S. 31, T. 24, R. 11 E., in *Bibb county,* mention is made of the fact that the ore lies imbedded in clay of red or yellowish red color, with streaks of a white clay (p. 495.)

In Talladega county, in the flatwoods, lying along the line of the Columbus & Western Railroad, in the southeast corner of S. 2, T. 21, R. 3 E., a white plastic clay which is said to have been penetrated to a depth of 35 feet, is reported to have been struck in a well. (p. 606.) In the same county in S. 19, T. 19, R.5 E., in the Charlton limonite bank there is a large "horse" of white clay, extensive deposits of white clay are noticed in connection with other limonite banks in the immediate vicinity. (p. 616.)

In *Calhoun county,* in T. 15, R. 8 E., and in Sections 21 and 23, there are many diggings in beds of limonite, and in most of them are "horses" of white clay, (p. 702). Again in T. 14, R. 8 E., in the same county, near Tampa, on land belonging to A. H. Tullis, Section 6, in the red residual clays derived from the disintegration of the limestones of the county, along with barite and limonite in pockets, are found some deposits of kaolin of white color and considerable thickness, up to 10 feet. In Section 5 of same township and range, the kaolin is exposedd in a cut of the East and West Alabama Railroad where it is 10 feet thick. (p. 715.)

In *Cherokee county,* to the northward of the line of the Southern Railroad in Sections 1 and 2 of T. 12, R. 11, E., there are many banks of limonite which have been extensively worked, and in some of them beds or "horses" of white clay have been exposed. One of these in the Clay limonite bank, in Section 2, the clay deposit is of great extent and several car loads have been taken from it and shipped to Chattanooga for manufacturing into fire brick. A similar white clay occurs in the Hickory Tree bank in Section 1, (p. 759.) The occurrence of the clay in the Dyke limonite bank, near Rock Run, is described on page 777. This is the kaolin whose analysis is given below under the number A. S. In the Washer bauxite band in S. 35, T. 12, R. 11 E., near Rock Run, and in the Warwhoop and other bauxite banks of the same vicinity, white clay and halloysite are of common occurrence. Some of these clays should be utilized.

Some details concerning them are to be found in the Valley Regions report, pages 780 to 789.

In the limonite banks to the eastward of Tecumseh furance in the same county, in T. 12, R. 12, E., clay *"horses"* are everywhere found separating the pockets of limonite, pages 792 and 793.

Accumulations of good plastic clay, which have evidently been deposited in the depressions of the limestone or in ponds, are not uncommon in the area of the great limestone formations. One such near Oxford in Calhoun county, is utilized by the Dixie Tile and Pottery Company. Analysis and physical tests of this clay are given in the body of this r port.

Of less purity on account of mixtures of sand, etc., similar deposits are numerous, and utilized in places, as, for example, the brick clay at DeArmanville in the Choccolocco valley.

SUB-CARBONIFEROUS FORMATION.

In the Sub-carboniferous formation of Wills' Valley is found the best known deposit of pure white clay of this section.

This clay occurs chiefly in the lower strata of the formation, generally very close above the Devonian Black Shale. The deposits which have, up to the present time, been pretty well proven, are to be found in the upper or northeastern end of Wills' Valley, near the Georgia line, and on both sides of the valley. The most important of them, however, occur on the eastern side of the valley. They have been described somewhat in detail by McCalley in Part II of his Valley Regions report, pages 175 to 182, from which the following details are compiled:

The Red Mountain ridges, made up of the strata of the Clinton, Devonian (Black Shale), and Sub-carboniferous formations, occur here as elsewhere in the State, on both sides of the valley. The ridge on the western side is, in general, lower and less continuous than that on the eastern side. The clay occurs in the lower strata of the Sub-carboniferous, not far above the Black Shale, and it has been "prospected" and found to be present in the ridges on both sides of the valley for some ten or twelve miles from the State line southward.

In the northwest corner of S. 3, T. 6, R. 9 E., on the west side of the valley, a test pit exposes the following section:

Section on west side of Wills' Valley, DeKalb Co.

Chert ledge weathered into a sandy rock of yellow color	8 to 12 inches.
Strata hidden by debris	2 to 3 feet.
White clay, without grit, in places like halloysite	8 feet.
Bluish colored clay	8 feet,
Strata not exposed	25 to 30 feet.
Devonian Black Shale	

The white clay occurrs in many places in this vicinity, and is called *chalk* by the people.

On the eastern side of the valley, the Red Mountain ridge, as stated above, is more prominent and continuous than on the west. Near the State line, about Eureka station and thence southwestward for a couple of miles, the clays have been tested and in many places worked. They have a thickness aggregating about 40 feet, but are said to thicken up occasionally to 180 to 200 feet, of which as much as 60 feet is a fine white clay suitable for the manufactory of stone ware. Some of the clay is shipped from here to the potteries at Trenton N. J., and some of it goes to Chattanooga, Tenn. *The Franklin (Ohio) Company Mines* are situated in the northern corner of S. 34, T. 4, R. 10 E. The clay is won by surface diggings, slopes, and tunnels, according to locality.

The following section is obtained along the wagon road through the surface diggings and will give a fairly correct idea of the occurrence.

Section at Franklin Company's Mines, DeKalb Co.

Alternations of chert layers, 4 to 18 inches thick, with fine sharp siliceous powder of white and yellow color	12 feet.
Chert of light yellow color, interlaminated with thin streaks of clay	12 feet.
Clay, mostly of yellow color, but with seams of white clay	10 feet.
Alternations of chert in layers of 2 to 8 inches thickness with clay seams 18 inches in thickness	4 feet.
Alternations of chert in layers 2 to 6 inches thick with white clay in irregular seams 6 to 12 inches thick	18 feet.
Clay, very gritty, of white color and chalky appearance	10 feet.
Clay and shale, the clay white and gritty, the shale green	10 feet.
Devonian Black Shale	....

In these mines in the upper twenty feet the clay is more siliceous than in the lower twenty feet. The siliceous clay is better suited for making fire brick, while the plastic clay is a potter's clay, commanding a good price. The chert which is interstratified

with the clay is also of value in the manufacture of stoneware.

In the N. E. ¼ of the S. E. ¼ of S. 4, T. 5, R. 10 E. are the *Montague Clay Mines,* worked by a tunnel on the southeastern side of the ridge. The clay is about thirty feet in thickness, some of it having a brown coloration, due to organic matter. It is quite uniform in composition for a distance for at least a mile in a northeast and southwest direction, is quite free from stains of iron but perhaps less plastic than the clay from some of the other localities near by. Most of the clay here mined goes to Chattanooga for the manufacture of fire brick. Two analyses of the clay from these mines are given by Dr. Ries under the numbers 116 and 117 and they are classed by him as fire clays.

Further southwest, along the ridge, we find other occurrences of the clay as in the S.W. ¼ of the N.W. ¼ of S. 12, T. 6, R. 9 E., where there is an old opening on a clay bed, which shows some four feet of clay. Still further southwestward in the N. W. ¼ of the S. E. ¼ of S. 15, T. 6. R. 9 E., there are numerous surface diggings, and tunnels in a clay bed thirty feet or more in thickness. Some of the clay of this deposit is of most beautiful quality, and especially well suited to the manufacture of the finest stone ware. A set of china ware, 700 pieces, made from this clay took a premium at the New Orleans Cotton Exposition.

In places the clay has streaks and stains, due to iron, and in other places it has a dark gray color, due to the presence of organic matter, which does not prevent its burning to a white color. Much of the clay is adapted to the manufacture of fire brick as shown by the analyses of a sample collected by Dr. Ries,

number 119. Analysis, number 214, shows the quality of the purer and whiter variety.

The clay deposits extend to within two or three feet of the Devonian Black Shale, thus fixing the occurrence at the base of the Subcarboniferous formation.

Beds of potter's clay of this formation have also been noted at other localities, among them one in the railroad cut just north of Stevens' switch on the A. G. S. R. R., and another in Calhoun county in S. 19, T. 15, R. 6 E.*

Hard white clay, like halloysite in appearance, has also been noticed at points in the Tennesseee valley, near Stevenson, and it is quite probable that search in that valley would be rewarded by the finding of deposits of the clay of commercial importance.

COAL MEASURES.

In some parts of the coal fields, the under clays of the seams of coal have been utilized in the manufactory of pottery, as at Jugtown, near Sterritt, in St. Clair county; at Fort Payne and Rodentown, in De-Kalb; at Vance's Station, in Tuscaloosa county; at Summit, in Blount county, and at Arab, in Marshall county. In all these places the clay is manufactured into jugs, flower pots and similar articles, while at Fort Payne it is also used in the manufacture of fire brick.

The shales of this formation are also utilized in some parts of the State, notably at Coaldale, where they are made into vitrified brick for paving purposes. At the Graves Coal Mine, near Birmingham, occur two bodies of shale, which have been analyzed and

*Valley Regions, Part II., pages 441 and 741.

otherwise tested for this report, and the results of these tests are to be found below, numbers 170 and 171.

Dr. Ries has tested also the Carboniferous shales from near Pearce's Mill, in Marion county, and finds them admirably suited for the manufacture of pressed brick and with a mixture of a more plastic clay suitable for the manufacture of terra-cotta (No. 3.) Up to the present time none of the clays from the Coal Measures have been found suitable for use in the manufacture of high grades of fire brick, but this may be due to the circumstance that very few of these clays have beeen examined. Of shales suitable for making vitrified brick, there is the greatest abundance.

CRETACEOUS FORMATION.

In many respects the most important formation of Alabama in respect of its clays, is the lowermost division of the Cretaceous, which we have called the Tuscaloosa. The strata composing this formation are prevalently yellowish and grayish sands, but subordinated to these are pink and light purple sands, thinly laminated, dark gray clays holding many well preserved leaf impressions, and great lenses of massive clays varying in quality from almost pure white burning clays to dark purple and mottled clays high in iron.

This formation occupies a belt of country extending from the northwestern corner of the State, around the edges of the Paleozoic formations to the Georgia state line at Columbus. Its greatest width is at the north-western boundary of the State, where it covers

an area in Alabama thirty or forty miles wide and about the same width in Mississippi.

From here towards the southeast the breadth of the belt gradually diminishes, till at Wetumpka and thence eastward to the State line, it forms the surface along a belt of only a few miles width.

To the eastward of the Alabama river, the proportion of clay to the rest of the strata is less than in the other direction, and at the same time the clays themselves are as a rule more sandy. But from the Alabama river northwestward, in the gullies, ravines, and railroad cuts, there are many exposures of these beds, exhibiting sections of clay beds from six to forty or fifty feet in thickness, and of varying degrees of purity. In a general way we may say that the purer clays, resmbling kaolin in composition, have as yet been found only in the northern part of this area in Fayette, Marion, Franklin and Colbert counties, and the adjoining parts of Mississippi.

In my Coastal Plain Report, published in 1894,* I have brought together many details concerning the Tuscaloosa formation in the counties of Lee, Russell, Macon, Elmore, Autauga, Chilton, Perry, Bibb, Tuscaloosa, Pickens, Lamar, Fayette, Marion, Franklin and Colbert, and the reader is referred to that book for full discussion of the formation.

In order, however, to present the clay occurrences as completely as possible I shall give extracts from the Coastal Plain Report in so far as they may be descriptive of the deposits of clay.

To these extracts are added a number of details received from a report made by Dr. George Little, who in 1891, spent several months making for the Geological Survey ,some examinations of the clays

*Pages 307-349, 531-2, 536, 541, 545, 549 551, 556, 559.

of this formation. Dr. Little brought together a large collection of the chief varieties of these clays and from these specimens, many of the analyses found in the report below have been made.

Use is also made of manuscript notes of my own on examinations made since 1894 and of descriptions of clay occurrences in the report on the Valley Reg'ons, Part I, by McCalley.

Inasmuch as the remarks of Dr. Eugene W. Hilgard on the clays of Missisipppi apply in general to the clays of this State which lie immediately adjacent to them on the east, a short extract from his Report on the Geology and Agriculture of Mississippi will not be out of place. These notes relate to the clays occurring in Townships 4, 5 and 6 in Tishomingo county, Mississippi, and were published in Dr. Hilgard's Report on the Geology and Agriculture of Mississippi, 1860.

"A large deposit of white clay of great purity, however, occurs in Tishomingo c ounty, chiefly in the southern portion of the territory of the Carboniferous formation, following very nearly its western outline. It there forms a regular stratum of considerable extent, which ,in one locality at least, was found to be more than 30 feet in thickness. The bed attains its best development, so far as the quality of the material is concerned, in the northern portion of Township 5 and in Township 4, Range 11 east, where it is about 30 feet underground in the uplands, though at times appearing in limited outcrops on the banks of the streams. Northeastward and southwestward from the regions mentioned, the bed also occurs but changed in character, at least near the surface, to a white gritty hardpan, or clays of various colors and of much less purity. It forms the lowest

visible portion of the Orange Sand formation, and is almost invariably overlaid by strata of pebbles and pudding stone, which in their turn are sometimes overlaid by common orange-colored sand.

The most southerly exposure of these beds, known to me, occurs on a small branch of McDouglas' Mill creek, in Sections 5, 4, and 9, Township 6, Range 10, east, near Mr. Pannel's place. For more than a mile along this branch there are exposures in which about 20 feet of a whitish mass, varying from a fine clayey sand to a white plastic clay, appears overlaid by thick beds (20 to 40 feet) of ferruginous pebble conglomerate; the latter in its turn being overlaid by the common ferruginous sand and brown sandstone on the hilltops. Similar outcrops appear in the neighborhood of Mr. Aleck Peden's place on Sections 3 and 27 ,Township 5, Range 10 east, northeast of Pannel's Here also a white stratum of which only a few feet are exhibited is overlaid by pebble conglomerate, and this by the common Orange Sand. The white mass varies from white plastic clay to fine grained aluminous sandstone; its upper layers are sometimes composed of a singular conglomerated mass, consisting of small, white quartz pebbles imbedded in pure white pipeclay. In both localities, copious springs of pure water are shed by the impervious clay strata. At Mr. Peden's, there is a fine bold chalybeate spring which seems, however, to derive its mineral ingredients (sulphates of iron and magnesia and common salt) from the adjacent Carboniferous strata rather than from those of the Orange Sand. In either of the localities mentioned, materials suited for fine pottery, or queenware, might be obtained.

Thence northwest, the stratum is not often found

outcropping, but, as had been stated, 20 to 30 feet below the surface of the uplands; the country being but slightly undulating. At Dr. Clingscale's, Section 8, Township 5, Range 11 east, the clay stratum was struck at the depth of about 30 feet beneath sand and pebbles; it was dug into, without being passed through, for nearly 30 feet more, no water being obtained from below, but dripping in above from the base of the pervious strata. The whiteness and plasticity of the material seems to increase with the depth. The portion of what was dug out of the well in question, had already been removed at the time of my visit, having been used for various economical purposes as, chalk, whitewash, and "Lily White". The specimens examined were, therefore, rather below the average quality, and on long exposure to the air, their surface shows some yellowish spots. I found nevertheless, that in baking at a high heat they yielded a biscuit of greater whiteness than their natural color when fresh; and that fine splinters, exposed for ten minutes to the highest heat of the mouth blowpipe, retained their shape perfectly while reduced to a semi-transparent frit. A quantitative analysis of the clay from Clingscale's well gave the following results:

White Pipe Clay from Clingscale's.

Insoluble matter	90.877
Lime	0.140
Magnesia	trace
Peroxide of iron	0.126
Alumina	2.214
Water	6.930
	99.864

This analysis (which was made solely for the purpose of ascertaining the ingredients foreign to the

clay proper) proves the singular fact that this clay, though occurring in a formation characterized by the large amount of iron it commonly bears, contains a remarkably small amount of that substance, which, together with minute porportions of lime and magnesia, explains its infusibility.

The two most important practical purposes which the materials occurring in the deposits just described will serve, are the manufacture of fine queenware and that of fire proof brick. (Not porcelain. Kaolin or porcelain earth contains, besides the white clay, a certain amount of undecomposed feldspar, which imparts to it its property of being semi-fused at the temperature of the porcelain kiln. The same property might be imparted to the white clay in question, by the artificial admixture of ground feldspar, but it could not thus compete with the naturel kaolin of Alabama).

As for the queenware, the plasticity of the material leaves nothing to be desired; and since the amount of siliceous matter varies greatly in different layers, there could be no difficulty about givng to the mass the precise degree of meagerness which may be found most advantageous, by mixing the several successive layers. The same may be said with reference to the manufacture of fire brick (to which these materials are admirably adapted), which would probably, at the present time, be the most feasible and most profitable manner in which the beds could be made available. The manufacture of fire brick differs from that of ordinary brick in this, that it requires more care, both in working the clay and in moulding the brick. Beyond their fireproof quality, it is demanded of fire brick *that their shape be perfect, their mass uniform and without flaws in the interior;* also that

they shall be liable to *the least possible shrinkage* in a high heat. The latter quality is imparted to them by a considerable mixture of either sand or ground fire brick to the fireproof clay, which itself ought to be thoroughly seasoned before, and then well worked up with such additions of the above materials as may be required. In judging of the amount of sand or ground brick to be added, it is to be observed, as a rule, to add as much as may be consistent with the proper firmness of the burnt brick and with convenient moulding. The latter process ought to be performed, as in the manufacture of pressed brick, whenever a first-class article is aimed at, for it is only thus that external and internal flaws are entirely avoided. In some localities materials may be probably found which require no further admixture—the strongly siliceous varieties of the clay; but whenever sand or burnt clay is added to the mass, care should be had that it be free from iron, which would seriously impair the fireproof qualities of the clay. None but white sand should be used. For the rest, they may be burnt in kilns like common brick."

RUSSELL AND MACON COUNTIES.

Within the limits of Girard and Phœnix City, opposite Columbus, and in the hills to the west of Girard, are many exposures of the Tuscaloosa strata, aggregating some 200 feet in thickness. These are composed mainly of sands, but there are numerous beds of white, gray and purple or mottled clays interstratified with the sands. The small stream which flows through Girard exposes a number of these clay beds, and others are to be seen in the hills to the west of the town. The materials for the manufacture of

drain pipe, vitrified brick, pressed brick etc., are here in abundance.

These clays are to be seen at intervals along the road leading toward Montgomery, e. g., near Marvyn, Crawford and Society Hill, the prevailing variety being the mottled red or purple clay. Northwest of Society Hill these clays occur as far as Farrell's Mill, in Macon county.

Near Cowles' Station, at the ferry across the Tallapoosa river, purple clays, three feet in thickness, show in the river bank, and a short distance further down the river at the site of Old Fort Decatur, a fine section of the Tuscaloosa beds, including many beds of clay from one foot thickness and upwards is exposed.*

ELMORE AND AUTAUGA COUNTIES.

In the vicinity of Old Coosada town, along the banks of the river, about Robinson Springs and Edgewood, there are many occurrences of the clays of this formation, analyses of which have been made by Dr. Ries, and the results given below in the body of the report. About Edgewood there are several potteries and one ochre mine using the materials of the Tuscaloosa formation. McLean, Vaughn and Boggs have potteries here, and Pressley has one further west.

At Chalk Bluff, near Edgewood, there is a very characteristic section exposed in an ancient bluff of the river, now at a distance of more than a mile from that stream. The section is as follows:

*Coastal Plain Report, p. 554, 556.

Section at Chalk Bluff, Elmore County.

1.	Layette red loam and pebbles...	15	feet
2.	Gray and yellow sandy clays, in distinct but irregular layers	6	"
3.	White clay, 3 feet graduating downwards into yellow ochreous clay, 3 feet	6	"
4.	Gray plastic clay blue when wet, and exceedingly tough and sticky; full of vegetable remains, flattened and bituminized	10	"

Two samples of this clay (Nos. 101 and 122) have been tested and analyzed by Dr. Ries (see below under the head of Pottery Clays and Brick Clays), where a section of this bluff is given, differing slightly from the above. This is not to be wondered at, since the stratification is very irregular, and no two sections, twenty feet apart, are idential.

Along the line of the Mobile and Ohio Ry., in Autagua, and on most of the pubilc roads leading from Prattville north and northwest, there are exposures of Tuscaloosa strata, consisting of sands and clays, the former predominating. In the western or northwestern part of the county, near Vineton, many instructive sections of the Tuscaloosa beds are to be seen. Some of these sections include beds of clay, which are of interest in our present work.

Section, near Col. J. W. Lapsley's place, Vineton.

1.	Stratified clays of white, pink, and purple colors, interlaminated with thin sheets of yellow sands; the lower part of this bed has a larger proportion of sand	10½	feet
2.	Gray laminated clay with partings of purple sands	5	"
3.	Yellowish white laminated clays, with purple and other bright colors on the dividing planes, 5 feet showing, but the same beds appear to continue down the hill for at least ten feet further	15	"

Section No. 2, near the preceding.

1.	Yellowish sands, beautifully cross-bedded....	4 feet
2.	White and pink clays, interbedded with yellow sands	10 "

Section No. 3, same locality.

1.	Purple clays interbedded with reddish sands..	6 feet
2.	Mottled (red and yellow) sandy clays, partly obscured by overlying pebbles and sands......	12 "
3.	Red sands with small lenticular bits of yellow clay......	5 "
4.	White and yellow laminated clays	6 to 8 "

At the bridge over Mulberry, near Vineton, the following strata are shown in the banks of the creek:

Section on Mulberry Creek, near Vineton.

1.	Mottled purple clays, similar to those at Steele's Bluff on Warrior River	5 feet
2.	Yellow cross sandy beds	2 "
3.	Mottled clays sandy below	5 "
4.	Grayish white micaceous sands, with irregular patches of red and yellow colors; to water's edge	4 "

BIBB COUNTY.

From Vineton up to Randolph very little of the strata of the Tuscaloosa formation can be seen until within three miles of the latter place, where dark purplish gray clays are to be encountered. Between Randolph and Centerville, along the public road, and at many points along the railroad from Mapleville to Centerville, there are occurrences of the massive clays of this formation. These clays have given much trouble and caused much expense to the railroad, from the fact that when softened by the winter rains they squeeze out into the railroad cuts, filling them up and overflowing the track. Where the clays from the cuts are used to make embankments, they are equally troublesome, as they are continually giving way. We

have no accurate notes of the sections exposed in the railroad cuts but the public road from Randolph to Centerville has been somewhat closely examined. At Soap Hill there is a typical section as follows:

Soap Hill, 7 miles East of Centerville.

1.	Purple and mottled clays at summit of hill...	5 feet
2.	Clayey sands in several ledges	10 "
3.	Cross bedded yellowish and whitish sands, traversed at intervals by ledges of sandstone formed by the induration of the cross-bedded sands	30 "
4.	Laminated gray clays with partings of sand..	10 "
5.	Alternations of laminated gray clays with cross-bedded sands in beds of 12 to 18 inches thickness	40 "
6.	Yellowish cross-bedded sands with clay partings	20 "
7.	Laminated gray sandy clays containing a few leaf impressions	10 "
8.	Grayish white sands	8 "

On the same road in the eastern part of the town of Centerville, on the School House Hill, there may be seen some fifteen feet thickness of purple and yellow clays.

The same beds show along the Selma road, south of Centerville, at many points. Sections are given in the Coastal Plain Report, pages 336 and 338. To the southwest of Centerville also, in townships 21 and 22, ranges 7 and 8, many of the ridges are composed of purple clays eight or ten feet in thickness, resting on four to six feet of gray clays.*

On the road to Tuscaloosa the clays show about half way between Centerville and Scottsville.

Along the line of the Alabama Great Southern Railroad in this county, there are many exposures of the Tuscaloosa clays, e .g. at Bibbville, where they have been utilized for many years in the manufacture of semi-refractory fire bricks for grates, etc. A great

*Costal Plain Report, page 338.

deal of the material is shipped now to Bessemer, where it is worked up into fire brick. Further north, near Woodstock again are rather extensive diggings on the line of the Birmingham Mineral Railroad, from which the clay is shipped to Bessemer and used as above indicated.

Dr. Ries has investigated the clays from both of these localities, and his results are given below in the body of the report, under No. 112 for the Bibbville's specimen, and No. 111 for that from Woodstock. He classes them with the fire clays. Another specimen from Woodstock, classed by Dr. Ries as brick clay, has been tested, (No. 126, A. Stevens).

TUSCALOOSA GOUNTY.

The utilization of the clays of this formation was begun in Tuscaloosa county by Daniel Cribbs in the year 1829. He was the pioneer, though it is said that W. D. Preston had a pottery in Autauga county in 1828. C. K. Oliver has had a pottery in this county since 1856. Peter Cribbs, in Lamar county, carried on the business for twenty-five years. He was the brother of Daniel, whose son, Harvey H. Cribbs, has for many years been more or less engaged in working the clays along Cribbs Creek, two miles south of Tuscaloosa, and later four miles east of town on the Alabama Great Southern Railroad. The Lloyd family have operated several potteries in Marion county, Alabama, and Itawamba county, Mississippi, for many years. Fleming W. Cribbs, a son of Peter, has now a pottery at the new town of Sulligent, on the K. C. M. & B. R. R.*

Within the limits of the city of Tuscaloosa there

*Notes of Dr. George Little.

are many exposures of the clays of this formation in the gullies facing the river bottom. In one of these gullies the section is as follows:

Section in Tuscaloosa.

1.	Pebbles, sand, and red loam of the Lafayette forming the plateau on which the city of Tuscaloosa stands	15 feet
2.	Light gray, somewhat massive clays, mottled with yellow, but becoming laminated below	8 "
3.	Dark blue, nearly black laminated clays, laminae half an inch thick, separated by thin partings of white sand. The clay contains leaf impressions	3 "
4.	Yellowish gray laminated clays, also containing impressions of variable thickness, average	2 "
5.	Strongly cross-bedded sands, yellowish to white, sharp, with a few streaks of clay irregularly distributed through it..........	20 "

At the proper depth below the surface, the clays above mentioned are encountered in most parts of the plain, though naturally the thickness of the beds and their character vary from place to place.

Eastward from the city the cuts of the A. G. S. railroad exposes these clays at numerous points. Some four miles from town they have been utilized by Mr. Harvey Cribbs in the manufacture of flower vases, jugs and similar wares. Below about twenty feet of the surface red loam and pebbles, we find at this place one to twelve feet of white clay, free from streaks; then three feet of yellow sand and a bed of blue clay of undetermined thickness.*

D. Ries' analysis and tests of the Cribbs' clays are given below under No. 1, S., where it is classed among the pottery clays.

At the Box Spring, about five miles east of Tuscaloosa, the railroad cuts expose about six or eight feet of laminated gray clays marked with purple streaks. Beyond Cottondale, nine miles from Tuscaloosa,

*Notes of Dr. George Little.

about thirty or forty feet thickness of purple clays is seen along the hillside.

Some twelve miles east of Tuscaloosa the grayish purple clays appear in many places along the slopes of the hills. The following general section of strata in this vicinity will give a good idea of the formation:

Section 10—12 miles East of Tuscaloosa.

1.	Purple massive clays	5 feet
2.	Ferruginous sandstone crusts	6 to 8 inches
3.	Variegated clayey sands holding small pieces of purple clay	10 feet
4.	Purple clays with partings of sand	10 "
5.	Ferruginous crust	1 "
6.	Laminated gray and yellow sandy clays	6 to 8 "
7.	Lignite with pyrite nodules	2 to 6 inches
8.	Dark gray somewhat massive clays	6 to 8 "
9.	Strata obscured by debris from above	20 "
10.	Purple clay at base of hill, thickness undermined.	

Along the A. G. S. R. R. beyond Cottondale, the cuts show many varieties of materials of this formation, among them beds of purple clays, sometimes massive, sometimes laminated. Just beyond Cottondale the clays gave much trouble many years ago at what was known as the "Sliding Cut."

A mile or two beyond Vance's Station, a bed of these clays is now being worked for material to use in the manufacture of fire brick at Bessemer.

Southward from Tuscaloosa the clays are seen in most of the hills bordering Big Sandy Creek, and judging from the width of the outcrop along the hillsides there can not be less than fifty feet thickness of them.

The same clays show along the A. G. S. railroad at Hull's Station, and all that vicinity, and Dr. Ries presents an analysis, together with the physical tests, of a sample of this clay, No. B., which he classes as a refractory or fire clay.

A characteristic section of these clays exposed

along the hillsides, just south of Big Sandy, where the Greensboro road passes, is given below:

Section on Big Sandy Creek, Tuscaloosa County.

1.	Purple or mottled clays, like those occurring at Steele's Bluff, on Warrior river......	30 feet
2.	Light yellow sands with pebbles, also similar to those seen at Steele's and White's Bluffs....	10 to 15 feet
3.	Gray, laminated clay, enclosing a lignitized tree trunk at base of hill......	4 to 5 feet

Further south the materials of the Tuscaloosa formation seem to be more sandy, and the proportion of clays is small.

Along the banks of the Warrior river below Tuscaloosa, the clays show up in many places, especially in the vicinity of Saunders' Ferry.

At the Snow place, above the ferry, there are some great gullies, in which these sands and clays of the formation are exposed. In some of the clay beds many leaf impressions have been obtained, which have assisted in the determination of the geological horizon of the Tuscaloosa formation.

A short distance above the ferry, and adjoining the Snow place, there is a bluff about 140 feet high which shows the clays and other beds of this formation very clearly. The section is as follows:

Section above Saunders' Ferry, Warrior River.

1.	Massive clays of greenish and purple colors, breaking with conchoidal fracture. On drying these clays become hard and rock-like. When wet by the winter rains, they soften and slide down the slopes, covering them completely in places. Thickness....	40 feet
2.	Laminated sandy clays, gray, with sand partings........	5 feet
3.	Gray cross-bedded sands, with partings of clay along many of the planes of false bedding........	25 feet
4.	Gray cross-bedded sands and blue micaceous sands......	23 feet

At Williford's landing the purple clays show about ten feet in thickness below the second bottom, or river deposits.

At Steele's Bluff, and a few miles below, at White's Bluff, similar purple or mottled clays make about ten feet thickness of the river bluff.

Westward and northwestward of Tuscaloosa the clays appear along all the roads for many miles to the western boundary of the county, and beyond into Pickens. The clays when freshly exposed are of gray color, but undergo a series of changes in consequence of weathering, and the oxidation of the iron which they contain. First, the gray becomes specked with red, and this color gradually increases in proportion until it prevails, and the whole body of clay becomes a dark red or purple mass, with few, if any, of the fragments of the original gray color.

At John Mills', about thirteen miles from Tuscaloosa, on the Shirley Bridge road, the following section is made by Dr. Little:

Section in Tuscaloosa County.

1.	Red loam and sand (Lafayette)............	10 feet
2.	Ferruginous sandstone crust....	6 feet
3.	Blue clay (Sample No. 1).................	6 feet
4.	Yellow sand, with indurated crust above and below........	7 feet
5.	Blue Clay (No. 2)..........	6 feet
4.	Yellow sand, with indurated crust above and	

On the Fayette Court House road the same clays show at many points, but the most promising clays along this road have been observed beyond the Tuscaloosa county line in Fayette.

The Mobile and Ohio road to the northwest of the city of Tuscaloosa exposes in many of its cuts beds of clay, which have been a source of much trouble and expense house of the filling of these cuts by the

softened clay during the winter seasons. Several cuts in the vicinity of Ten Mile Cut have traversed these beds of clay. One specimen from the Ten Mile Cut has been examined by Dr. Ries, and classed among the brick clays (No. A), though, as Dr. Ries remarks, there is no reason why it should not find other uses as well.

In the near vicinity of this cut, on land formerly occupied by Mr. J. C. Bean, occur three beds of clay measuring each about five feet thickness. These have been investigated by Dr. Ries under the Nos. 118, 115 and 100. The first of these, classed as fire clay, has many points of interest, growing out of its dense burning at low temperature, and the great difference in temperature between the points of incipient fusion and vitrification, suggesting its suitability for use as a glass-pot clay. The other two clays are classed as pottery clays, and are perhaps representative of one of the most widely distributed types of the clays of this formation.

PICKENS COUNTY.

Near the line of the M. & O. road, in this county, the clays are observed from the Tuscaloosa county line to within nine miles of Columbus. In mode of occurrence and in the character of the clay these beds resemble those of Tuscaloosa, above mentioned. From Roberts' Mill on Coal Fire Creek, Dr. Little has collected a sample of white clay which has been analyzed by Dr. Ries, No. 32 S. It is classed by him among the stone-ware clays, burning to buff color, and is in many respects similar to the Cribb's clay of Tuscaloosa. West of Coal Fire Creek, and at a distance of 18 to 20 miles from Columbus, the massive reddish clays show in the hills to a thickness of 40 to 50 feet.*

*Notes of Dr. George Little.

LAMAR COUNTY.

The strata of the Tuscaloosa formation cover the entire area of Lamar below the mantle of red loam and pebbles of the Lafayette. Among the strata are numerous beds of clay of varying degrees of purity. Dr. Little's notes, which follow below, give many details concerning them.

Along the line of the Southern (Georgia Pacific) Railroad, there are many exposures of the clays, as at Millport, where the clay shows at a thickness of four feet; beyond this at about 23 miles from Fayette Court-House, the clay seems to be 10 feet thick, and near this at Fernbank, J. D. Green has a pottery. His clay is 18 feet thick, analysis of this clay is to be found in Dr. Ries' report, No. 27 S.

Along the road from Fayette Court House to Vernon, at 9 miles from the former place we have this section.

Section nine miles west of Fayette C. H., in Lamar Co.

Blue clay	6 feet
Mottled clay	20 feet
Sandy clay	4 feet

Three miles further west on the same road, this clay is some 20 feet in thickness. Within two miles of Vernon, in A. W. Nichol's well, blue clay 8 feet thick is penetrated below six feet of overlying sands.

One mile east of Vernon, at a saw mill, there is clay, white and 3 feet in thickness.

On the old military road of Gen. Jackson at a distance of 20 miles from Columbus, Miss., and about 7 or 8 miles northwest of Vernon, near Bedford P. O., are the remains of a pottery once owned by Peter Cribbs. At this place lives Captain Cribbs, a negro man with his son, Major. Captain worked for

many years in the potteries, which his master, Peter Cribbs and his master's widow, managed from 1865 to 1886. The pottery, 3 miles further north on the Military road near M. P. Young's, was the place where most of the jugs, jars, etc., were made. The best of the clay for these potteries was obtained from what is now Reuben Powell's land, 2 miles west of the Military road in the northwest quarter of the norhwest quarter of S. 28, T. 14, R. 16. The pits were dug 14 feet down to the clay, which was 3 feet thick. Mr. Powell has bored with an 8 inch augur near this place, and found clay 1½ feet from the surface, 5 feet thick, dark brown and very tough and plastic. Analysis of this clay is given by Dr. Ries under No. 11 S.

Lewis J. Jones, who now lives on the Powell place in the southwest quarter of southwest quarter of Section 23, has bored a well in his yard of which the section is as follows:

Section in Well, Lamar Co.

Surface sands and loams	12	feet
Clay	1½	feet
Sand	9	feet
Clay	2	feet
White sand	24	feet
Clay, penetrated to depth of	2	feet
but so tough that the auger could not be raised, and the well was stopped.		

Clay is also reported at Thomas' Mills, above Hunnel's Bluff on Buttahatchie creek and on Wilson's creek near Friendship Church.

Westward from the Military road, the clay territory continues to within 10 miles of Aberdeen, where level land and white sandy soil set in.

Gattman is on the Mississippi State line, and just west of it across Buttahatchie is Greenwood Springs,4 miles from Quincy in Monroe county, Mississippi.

One and a half miles south of these Springs, there is a railroad cut 85 feet in depth, the largest cut on the road, (K. C. M. & B.) 110 miles from Birmingham. In this cut we find the following section:

Sections along K. C. M. & B. R. R., Lamar Co,

Yellow loam.......	5 feet
Yellow sand..........	15 feet
Yellow sand with streaks of clay...............	5 feet
Blue micaceous clay, sample No. 11, A...........	5 feet

Half a mile further west another section:

Yellow clay...........	5 feet
Ferruginous sandstone, used for ballast..........	10 feet
Yellow sand......	20 feet
Clay with sandy layers......	8 feet
Compact b'ue micaceous clay, sandy.............	12 feet

At mile post 111, the section is:

Red clay....	10 feet
Banded red and white c ay....	10 feet
Pore, sand	10 feet

Half a mile west of the 111 mile post, the section is:

Red loam of the Lafayette formation...........	5 feet
Bright yellow sand........	30 feet
Clay......	2 feet
Light yellow sandy clay......	20 feet
Red and white clay.............	5 feet

Near the State line, on the Kansas City, Memphis and Birmingham Railroad, 3 miles from Sulligent on the west side of Buttahatchie, a pottery has been operated. At Sulligent, Fleming W. Cribbs has lately started a pottery. He is a son of Peter Cribbs and nephew of Daniel Cribbs. His clay bed is one-half mile east of Sulligent and is 4 feet thick, and white. He says that his father carried on the business from 1838 to 1853 when he died, and his widow continued the work to 1863, his account agreeing with that of the negro, Captain, nearly as to time of operation,

but placing it in entirely different decades. He has orders now for 5000 gallons (jugs) from Birmingham and Bessemer, at eight cents a gallon. He has two hogback kilns with a capacity of 800 jugs each. His clay is found in a washed out old road and is overlaid by 10 feet gravel.

Rye has a pottery, 6 miles north of Millville, Detroit P. O. Davidson Brothers have one also in same neighborhood. Lloyd has one near the Mississippi line in Itawamba county. These compete with potteries at Holly Springs, Mississippi, and Pinson's 12 miles from Jackson Tenn., for the West Tenn. and Miss. trade. From State line at Gattman to Glenn Allen, clays are very abundant and of fine quality all along the Kansas City Railroad, and this is destined to be an important center of trade in all kinds of clay manufacture. Beaver Creek flows nearly west, parallel with the railroad. Beaverton is a station on Section 17, Township 13, Range 14 west. One mile west of William Brown's place, Section 10, and on Edmund Barnes', Section 16 and on Ira Sizemore's, Section 17, clay abounds. Brown has ten feet blue clay overlaid by 10 feet cross banded yellow sand. 5 miles east of Beaverton and 2 miles west of Guin, there is 10 feet white and yellow sand and underlaid by 3 inches of ferruginous conglomerate.

FAYETTE COUNTY.

Over the greater part of the area of Fayette county, the strata of the Coal Measures are covered, to a depth increasing as we go westward, by beds of the Tuscaloosa formation capped with the red loam and pebbles of the Lafayette. Among the strata of the Tuscaloosa there are many beds of clay of purple, gray and white colors. About the Court House, a bed

of white clay is reached at many points below a varying thickness of overlying strata. Thus at Mr. Sam Appling's a bed of fine white clay, 6 feet in thickness, is cut in a well, and apparently the same bed is known to underly the region about the depot. Mr. Appling's is in Section 24, Township 15, Range 13 west.

From Dr. Little's notes, I am able to give a number of details of the occurrences of these clays. Seven miles from Fayette Court House, on the road to McCollum's Bridge, is a bed of three feet thickness of very pure clay ,hard and firm, which breaks up on exposure into nodules, and the same bed shows on another road to the west of this about one mile, south of Wallace's Mill on Gilpin's creek, on W. D. Bagwell's land.

Dr. Ries' analysis of this clay is to be found in the report under number 67, S.

On the road to Pikeville, seven miles from Fayette Court House, we have the following section:

Section seven miles north of Court House, Fayette Co.

Red loam of Lafayette	2 feet
Gravel	10 feet
Clay	3 feet
Gravel	3 feet

Between the depot and the Court House Dr. Little has observed three feet of good white plastic clay in a ravine on the roadside, and the same bed is exposed in the ravines at many points on the eastern edge of the old town. Five miles west of the Court House on the Vernon road, some tan-yard vats were dug years ago, three feet into a blue clay. About half a mile from the depot, Mr. Joe Lindsay reports fine white clay, twelve feet below the surface, which, he says, was twenty feet thick.

To the westward and southwestward of the town

along the line of the railroad, the clay shows in a cut one mile from the depot. On the Columbus road, four miles from Fayette, a six foot bed of clay is recorded, and five miles further west, at Hezekiah Wiggins' a bed of blue clay, four feet thick. Dr. Ries has tested and analyzed this clay under No. 32, S.

Half a mile further west, at Henry Wiggin's, there is a bored well, eighty feet deep, which, below the depth of fifteen feet, seems to be mostly in clay. One fourth of a mile beyond this, near Waldrop's, a bed of blue clay, 10 fet thick, shows at the bottom of a hill, and fifteen feet higher up another bed appears.

Along the road to Tuscaloosa at seven miles from Fayette, and also a mile further on, clay, three feet in thickness, is exposed. Again in section 13, township 17, range 12, about a quarter of a mile from Shirley's Mill, several beds of clay are shown along a hill side. One of these beds, a brown clay, about three feet in thickness, is full of finely preserved leaf impressions. and below it a fine sandy clay of three feet thickness. This is near the 11 mile post from Fayette.

Dr. Ries has analyzed two samples of the clay from this place under the numbers 68, S., and 110, and the reader is referred to these analyses and the remarks of Dr. Ries below.

Two miles southwest of Shirley's Mill on Davis' Creek, J. W. Black reports four feet of blue clay in section 25, township 17, range 12 west.

Near Doty's place, one mile east of Concord Church and about thirteen miles from Fayette, there is the following section exposed in a gully:

Section near Doty's, Fayette Co.

Red loam and sands of the Lafayette	4 feet
Ferruginous sandstone crust	2 inches
White clay (No. 7, Dr. Ries)	6 feet
Yellow sand	5 feet
Variegated clay (No. 71, Dr. Ries)	2 feet
White sand	2 feet
Mottled clay, red and white	3 feet

Dr. Ries' analyses of the two clays here exposed may be seen below under numbers 70 and 71.

MARION COUNTY.

While the strata of the Coal Measures underlie the entire area of Marion county, yet these rocks do not form the surface over any great proportion of this area, since they are very generally hidden, except along the valleys of the streams, by overlying measures of the Tuscaloosa and Lafayette formations. Among the strata of the Tuscaloosa, here as in Fayette, we find many fine beds of clay. Here again, Dr. Little has collected many details of the occurrence of these clays and what follows we take mainly from his notes, though use is made also of what has been published in my Coastal Plain Report, pages 331, 332 and 333.

In the lower part of the county along the line of the K. C. M. & B Railroad, clays are exposed in railroad cuts all the way from Eldridge to Guin.

From New River crossing near Texas P. O., on to Glen Allen, several beds of clay, of no great thickness, are to be seen. A mile east of Glen Allen, in what is known as Stewart's Cut, we have the following section:

Stewart's Cut, one mile east of Glen Allen.

Gray laminated clay with fine leaf impressions...	25 feet
Ferruginous sandstone crust of irregular thickness	1 foot
Cross-bedded sands of yellow and pink colors.....	25 feet

The uppermost of the beds, above named, contains many beautifully preserved leaf impressions which are very easily gotten out. The clay has been examined by Dr. Ries under No. 18, S.

At another cut, half a mile nearer Glen Allen, we

find twenty feet of white sand with two feet of white clay, and below this a blue plastic clay extending below the railroad track.

This sand has been shipped to Memphis as moulding sand for the foundry. At Glen Allen, Dr. Little gives this section:

Section at Glen Allen, Marion Co.

Brown clay	12 feet
Yellow sand	12 feet
White pipe clay	2 feet

Two miles east of Guin, on the same road, Dr. Little observes five feet of clay below a capping of red sand, and one mile west of Guin, (six miles from Beaverton) he gives the following section:

Section near Gwin, Marion Co.

Cross-bedded yellow sands	10 feet
Clay	4 feet
Sand	3 feet
Banded clay	3 feet
Sand	3 feet

On the South Fork of Buttahatchie in the vicinity of Pearce's Mill, there are several occurrences of clay and shale worth consideration. Dr. Riës collected specimens from near the mill and gives his analyses of two samples under No. 1 and No. 2, both of which he classes as refractory or fire-clays. He also gives his tests of some shales of the Carboniferous formation, which are well adapted to the manufacture of vitrified brick (No. 3). Another sample of hard and perfectly white clay was collected by Dr. Little from near the top of a hill one-fourth of a mile east of the mill. This Dr. Ries has analyzed under No. 36, S., and it is classed by him as a china clay. Dr. Little reports that, in pulverized condition, it is used as a face powder by the ladies in the vicinity.

It is, however, in Townships 9 and 10 and Ranges 11, 12 and 13, that we find the most important deposits of clay in this county. The typical locality of its occurrence is at *Chalk Bluff*, which gets its name from the white clay. Specimens collected by myself were analyzed by Dr. Wm. B. Phillips and results published in the Coastal Plain report, page 346. Dr. Little's sample was collected on the land of J. J. Mitchell, in northeast quarter of Section 8, Township 10, Range 13, from a bed five feet in thickness. The analysis of this is given below under No. 38, S., and on the same page Dr. Phillips' analysis is reprinted. This locality gives the name to the postoffice. In the same quarter section, Dr. Little has collected a sample from Briggs Frederick's land, and the analysis of this is given by Dr. Ries under No. 37, S.

Another sample from the same locality from land of Mrs. Susan Nelson, has been examined by Dr. Ries (his number 85). The same clay is reported by Dr. Little as occurring southwest of Chalk Bluff at M. E. Gassett's, Section 13, Township 13, Range 10, as well as at a number of localities within a radius of five or six miles around Chalk Bluff. This clay is hard and white, approaching pure kaolin in composition. It is in a bed, five to seven feet in thickness, and needs only facilities for transportation to become one of the most valuable deposits in the State.

Between Pikeville and Hamilton, clays are of frequent occurrence, one of these near the former place and some ten miles from Hamilton, collected by Dr. Little has been analyzed by Dr. Ries, (No. 65, S.)

Westward from Hamilton to the Mississippi line and beyond, Dr. Little reports many occurrences of clay of various qualities. From the vicinity of Bexar, three samples of clay have been collected by

Dr. Little and analyzed by Dr. Ries, (numbers 12, 40 S. and 41 S.). The bed in this region is about four feet in thickness. Nos. 12 and 40 are from H. Palmer's and No. 41 from Bexar, a mile further west, near Pearce's Store and Mill.

Near the State line on the road to Tremont, Miss., twenty feet thickness of clay is reported as being cut in a well.

Beyond the State line, the clays continue, and at Davidson's Store, Lloyd's pottery, they are put to a rather remarkable use, namely for head stones of graves, for which purpose they are moulded into flat tablets, provided with suitable inscriptions and then baked. These stones appear to be quite durable although necessarily liable to be broken.

A number of potteries in this vicinity use this clay which is about four feet in thickness, and quite similar to that mentioned above as occurring about Gattman in Lamar county, on the K. C. M. & B. Railroad.

The Bexar variety of clay extends for a good many miles northward up Hurricane Fork and along Bull Mountain Creek.

FRANKLIN COUNTY.

In Franklin county the underlying Paleozoic rocks of Carboniferous and Subcarboniferous ages are exposed along the valleys of the streams, but everywhere else are covered with a mantle of varying thickness of the sands, clays and pebbles of the Tuscaloosa and Lafayette formations.

As in the other counties adjoining towards the south, so in this, it is in the Tuscaloosa strata that we find the important deposits of clay. In parts of the county, especially in the vicinity of Russellville, val-

uable deposits of limonite or brown iron ore have been for many years and are now being worked to supply the furnaces at Sheffield and Florence.

Associated with these ore beds are *clay horses,* as they are called, which, in places, yield an abundance of fine white clay.*

Other occurrences of the clays of the Tuscaloosa formation, not associated with the iron ores, have been recorded by Dr. Little, from whose notes the following details have been obtained.

On the southern boundary of the county, near Savoy postoffice, in T. 8, R. 14, near Dr. Kilgore's Mill, a bed of blue plastic clay three feet thick is noted, above which, one hundred feet up the hill, is a bed of four feet thickness of red clay or ochre (red chalk), and just above this a bed four feet thick of pure, hard, white clay, like that of Chalk Bluff, in Marion county. The same beds are to be seen at many points around Savoy within a radius of three miles. Half a mile west of Burleson a bed three feet in thickness of white clay is found immediately overlying the blue limestone of the Subcarboniferous formation. Along the road from Burleson to Belgreen the clay is exposed at several points.

Northwest of Russellville, on the road to Frankfort, large deposits of white clay were reported, but not seen by Dr. Little.

Near the State line, in S. 9, T. 7, R. 15, on Gilley's branch, occurs a bed of clay from which material has been obtained for a pottery formerly worked by Mr. Chaney, two miles east of Pleasant Ridge, Miss.

Southward of this locality, in S. 20 and S. 29, of T. 8, R. 15, Mr. Thomas Rollins has a bed of clay four

*Valley Regions Report, Part I, pages 211 and 215.

feet in thickness, a sample from which has been tested by Dr. Ries, No. 62 S. The country for several miles in all directions about Rollins' is rough and hilly, the hills capped with beds of pebbles and a ferruginous sandstone crust, but the beds of clay, interstratified with sands, seem to make up a very considerable proportion of their bulk.

COLBERT COUNTY.

In the northern and eastern parts of this county the strata of the Subcarboniferous formation make the surface, but in the southern and western parts these older formations are covered by the mantle of sands, pebbles and clays of Tuscaloosa and Lafayette formations, the former of which carries the important clay deposits here as elsewhere. The best of these clays occur near the western border of the county, as well as in the adjacent parts of Mississippi.

The station Pegram, on the Memphis and Charleston Railroad, seems to be about the central point in this clay region. Some extensive works for the manufacture of fire brick and other kinds of brick have been established here under the name of the "Alabama Fire Brick Works." The clay is obtained from the southwest part of S. 27, the northeastern part of S. 3, and the northwestern part of S. 34, in T. 3, R. 15 W. The clay appears in several beds, as shown by the section below, which is taken from the notes of Dr. Little.

Section near Pegram, Colbert Co.

Pebbles of large size with sands................	30 feet
White clay, one-eighth of a mile from mill.......	3 feet
Small gravel..........	1 foot
White clay, sample No. 55, S..................	6 feet
Sand with large gravel overlying..............	16 feet
Yellow clay, sample No. 56, S..................	6 feet
White clay.......	1 foot
Purple and black clay, sample No. 57, S..........	10 feet
Gray clay, sample No. 58....	5 feet

On land belonging to Mrs. C. Rhea, in the vicinity, Dr. Little gives the section as follows:

Yellow loam......	1 foot
Sandy clay (fire clay), sample No. 59..........	5 feet

Of these clays Dr. Ries has analyzed and tested Nos. 55, 56 and 57; No. 56 being classed by him among the china clays, while the other two are ranked as fire clays. The brick from this locality are used in Sheffield for lining the furnaces, and they are also used by the railroad.

In the Valley Regions Report, Part I, are given three analyses of clays collected from this region near the State line. These are as below:

Analyses of Clays from near Pegram.

	1.	2.	3.
Combined water......	8.250	6.827	7.085
Silica........	66.122	76.911	68.108
Alumina....	24.781	11.173	10.858
Ferric oxide....	trace	3.449	14.471
Total....	99.153	99.360	100.522

(1.) A light colored clay with small lumps of gritty matter.
(2.) A dark gray clay with black specks of organic matter.
(3.) A pinkish clay with white specks.

The light colored clay (1) above has been seen also on the south side of Little Mountain, near the bottom of the pebble hills, along the county line, a few miles northeast of Frankfort. It shows here in an irregularly stratified seam beneath the pebble bed. It is quite pure and white, and has occasionally found use as a whitewash, for which purpose it seems well adapted.*

*Valley Regions, Part I, page 180.

LAUDERDALE COUNTY.

The Tuscaloosa formation, which carries the clay deposits, covers only the western half of Lauderdale, the Subcarboniferous rocks forming the surface over the eastern half. The clays are white, red and mottled, and generally quite plastic. Mr. McCalley gives some notes concerning them.

At the Tan-Yard Spring, in the N. E. ¼ of the N. W. ¼ of S. 24, T. 1, R. 14 W., there is the following section:

Section at Tan Yard Spring, Lauderdale Co.

Ferruginous crusts........	1 foot
Clay, somewhat stained with iron, unctious and plastic when wet..........	5 feet

This clay has been analyzed by Dr. Pickel, of the University of Alabama, with the following results:

Analysis of Clay, Tan Yard Spring, Lauderdale Co.

Silica......	59.65
Aumina....	27.04
Ferric oxide..........	4.75

In the gullies, near the top of the divide between Brush and Bluff creeks, in the southwest of the northeast of S. 30, T. 1, R. 13 W., there are deposits of white unctuous clay from seven to eight feet thick.*

Dr. Little's notes supply some additional information about the clays of this county. Mr. Wm. J. Beckwith has a clay deposit four and one-half miles from Wright's postoffice, on Brush Creek. It is upon a high hill, and is five or six feet in thickness. The clay is of a light yellow color, and is firm, fine grained and smooth. It has been shipped north and

*Valley Regions, Part I, page 105.

sold for $12 a barrel, and can be delivered, barreled, on the boat on the Tennessee river for $1 a barrel.

There is a red clay, suitable for paint, belonging to the Sheffield Paint Company, near the county line, six miles from Iuka, Miss. The bed is ten feet thick. The white clay from Clingscale's Mill, Miss., mentioned above in the extract from Dr. Hilgard's report, comes from localities near the State line, west of Lauderdale county.

In many parts of this county there are beds of white pulverulent silica, which have occcasionally found use. Thus at Florence the Mineral Paint and Tripoli Company make a paint by mixing clay and this fine silica together. At Waterloo, also, the same white silica appears, as at Eastport, in Colbert county. This material has been used in the manufacture of glass at Pittsburg, Pa.

TERTIARY AND POST TERTIARY FORMATIONS.

The clays from these two formations have not yet been specially investigated, the only representative herein contained being the flint clay from Choctaw county. The material is spoken of under the head of Fire Clays. There is a very great abundance of this clay in the counties of Choctaw, Clarke, Conecuh, etc., in the lower Claiborne or Buhrstone division of the Tertiary. Over the greater part of the Coastal Plain, in the river second bottom or Post Tertiary formations, there is the best of the yellow loams which are suitable for the making of the ordinary building brick. These loams correspond in age, approximately, to the Plisocene clays of the northern states, which are so extensively used for the same purposes. Besides these second bottom deposits,

there are lens of pure plastic clays to be found in many places interstratified with the prevailing sands of the formation. Many of these clays have been received and superficially tested, but it is the intention to extend the present investigation over that part of the state in the near future.

III

PRELIMINARY REPORT OF THE PHYSICAL AND CHEMICAL PROPERTIES OF THE CLAYS OF ALABAMA,

BY HEINRICH RIES, PH. D.

The tests which are described below were made in part on samples collected by the writer, and in part on samples collected by Prof. Smith. In the examination of the different lots of clay an endeavor has been made to perform such tests on the materials as would tend to give information of value to the practical clay worker.

This therefore includes the determination of the shrinkage of the clay in drying and burning, the degree of its plasticity, the color when burned at different temperatures, the temperature of incipient fusion, vitrification, and viscosity, and other minor points.

In some cases it is possible to state what the possible applications of a given clay are, but in many instances any one clay is susceptible of being mixed with two or three other clays and utilized in four or five different ways. The main point therefore, is to point out the properties of the deposits, so that the manufacturer may find out more readily whether the State contains materials of the nature desired by him, and in what portion of the State they are to be found.

It may be said in general that the results of the tests made indicate the occurrence of a great diversity of clays in the State, ranging from the more impure and easily

fusible ones to the very refractory bauxites, which are unaffected by high temperatures.

These investigations relate chiefly to those deposits which have not yet been worked, with a view to aid the development of Alabama's clay resources; and consequently little is said with regard to the industry already established.

Where a number in parenthesis follows the name of the locality, it refers to the number in the writer's note book, unless succeeded by the letter S in which case the number is that on the label furnished by Dr. Smith.

The clays examined by me have been classified below as follows: China Clays; Fire Clays; Potters' Clays; Brick Clays; Miscellaneous Clays, and a few pages have been added on the utilization of clays, in the manufacture of Portland Cement.

CHINA CLAYS.

China clays might include those used in the manufacture of porcelain and white earthenware, and of these, two grades are recognized, i. e., kaolins, or china clay proper, and ball clays. The former possess little plasticity, a low percentage of fusible impurities, are generally highly refractory and burn to a pure white body. Very few kaolins can be put on the market in the condition in which they are mined, and most of them have to be washed in order to eliminate impurities which would tend either to discolor the clay or to render the texture far too coarse. The tensile strength of kaolins may vary from 5 to 15 lbs. or even reach 25 lbs., and the influence of this low strength is overcome by the addition of plastic ball clay. Iron is a very objectional impurity and should not exceed 1 per cent. indeed the less of it the better. Alkalies, if present as silicates, are not wholly undesirable for they serve as beneficial fluxes, but if contained in the

clay as sulphates they may cause blisters, especially if the clay is heated too rapidly, and the same holds true of sulphate of lime or gypsum. Many washed kaolins approach very closely to the theoretical composition of kaolinite, while others (even when washed may contain a high percentage of total silica due to the presence of much quartz and perhaps feldspar. If these two accessory minerals contain no iron they are harmless, especially if finely divided, and the rational analysis of clay is known. (See method of clay analysis.) The term kaolin is usually, and always should be restricted to white burning clays of residual origin. They are in most instances highly refractory, but they might also be of such composition as to bring about fusion at a low temperature, and at the same time burn white. It is the absence of plasticity in kaolins that necessitates the addition of ball clay, but some manufacturers use only the ball clay, mixed with quartz and feldspar for making porcelain. The last two minerals are indispensable ingredients of white-ware mixture, quartz being added for the purpose of preventing excessive shrinkage, and feldspar on account of its easy fusibility binding the mass together.

China clays should contain a low percentage of iron oxide, in fact the less the better, for in burning this compound tends to color the clay yellow or red. While the percentage of iron oxide should be under 1 per cent., nevertheless many of the best china clays used contain 1.25 to 1.35 per cent. of iron oxide. This production of a yellowish tint from such a quantity is prevented in two ways, first by adding a small amount of cobalt oxide to the white-ware mixture, or secondly by taking advantage of the fact that when the kiln, in which the ware is burned, is heated to a high temperature the fire tends to act reducing, thereby changing the iron coloration from yellow to bluish or bluish gray, and making it less noticeable.

Ball clays are used to mix with kaolin in the manufacture of porcelain and white-ware in order to give plasticity to the mass. They should be as free from fluxing impurities and mineral fragments as possible, and sometimes have to be washed. They generally burn nearly as white as kaolin. Ball clays should have a good tensile strength, not less than 60 lbs. to the square inch. They are often dark brown or even black from the presence of abundant organic matter, but this color disappears on heating. This organic matter exerts no other effect on the clay than to increase the plasticity and air-shrinkage.

The Alabama clays included under this heading are those which burn white or very nearly so at a moderately high temperature. Many of the specimens examined are quite siliceous, and consequently exhibit a low shrinkage in burning, while nearly all of them are of sedimentary origin. a few, such as those associated with the bauxite deposits, having an origin in common with them.

In respect to their geological relations the china clays here reported on come from three horizons, (1) the Cambrian and Silurian limestone, e. g. No. A. S. from Rock Run; No. 190 from near Gadsden; and No. 205 from near Kymulga, in Talladega Co. (2) the lower Sub-carboniferous cherty limestone; e. g. Nos. B. S; 128, and 214, from Willis' Valley, between Fort Payne and the Georgia state line. (3) the lower Cretaceous or Tuscaloosa formation, e. g. No. 38. S; No. 85; No. 37. S from Chalk Bluff and vicinity, Marion county: No. 37. S from Pearce's Mill, Marion county. and No. 56. S from Pegram in Colbert county.

Of the above, only the clays from Will's Valley have been regularly mined.

CHINA CLAY.

FROM DYKE'S ORE BANK, ROCK RUN, CHEROKEE CO. (NO. A. S.)

A white, soft, gritty clay, which slakes easily in water.

The clay requires the addition of 30 per cent. of water to make a workable mass, which is quite lean. Bricklets made from this shrunk 4 per cent. in drying and an additional 12 per cent. in burning, making a total shrinkage of 16 per cent.

The tensile strength of the air dried briquettes is low, being only 9 lbs. per square inch on the average, with a maximum of 12 lbs. per square inch.

Incipient fusion occurs at 2000 degrees, F. The clay burns to a hard, marble like, dense body with a very faint bluish tinge at 2100 degrees F.

The analysis of the clay is as given below.

Analysis of China Clay, Rock Run, Cherokee Co. (No. A. S.)

Silica	60.50
Alumina	26.55
Water	7.20
Ferric oxide	.30
Lime	.90
Magnesia	.65
Alkalies	2.70
Moisture	.70
	99.50
Total fluxes	4.55
Specific gravity	2.52

The rational composition is

Clay substance	70.30
Quartz	18.00
Feldspar	12.20
	100.50

This clay possesses an advantage in the density produced by moderate burning but its high shrinkage would have to be counteracted by the addition of more quartz.

CHINA CLAY.

FROM J. R. HUGHES, GADSDEN, ALA., (NO. 190.)

In the lump specimens this clay shows little evidence of stratification. It is mostly white in color, and on the average very fine grained 95 per cent of a lot of the sample sent passing through a 150 mesh sieve. There are scattered through it occasional lumps of the halloysite, so that the material would either have to be ground or washed before shipping it to market. The latter course would be more advisable as it at times shows yellow patches of color. When thrown into water the clay slakes moderately fast to flocculent particles. In washing it tends to stick on the sieve somewhat, and this might cause trouble in pottery manufacture unless ground quartz and feldspar were mixed with it in the proper proportions.

In working it up with water 37.50 per cent of water were required, and gave a mass of high plasticity.

The bricklets made from this had an air shrinking of 8 per cent.

In burning a noticeable property is the great density attained at a comparatively low temperature, but this is also accompanied by an additional though not great shrinkage. Thus, at about 2130 F. the total shrinkage was about 14 per cent. and the bricklet very dense; The color was white. At 2250 F. the shrinkage was 15 per cent. and the color white with a faint tinge of gray. At 2350 F. the shrinkage remained the same, and the color white with a faint cream tinge. Incipient fusion began at 2250 F.

The clay fused at cone 27 in the Deville furnace.

The clay has to be heated very slowly in burning in order to prevent cracking.

The tensile strength of the briquettes was tried in several different ways.

One lot was made from clay ground to pass through a 20 mesh sieve, and these showed a tensile strength of 137 lbs. per square inch, the maximum being 154 lbs, the variation in the different briquettes being 20 per cent. A second lot was ground to pass through a 60 mesh sieve, and here the average strength was 138 lbs. per square inch, the maximum being 143 lbs. and the variation 12 per cent.

A third lot was ground to pass through a 100 mesh sieve and here the average tensile strength was 132 lbs. per square inch with a maximum of 150 lbs. and a variation of 15 per cent.

The chemical analysis of this clay yielded:

Analysis of China Clay, J. R. Hughes. Gadsden. (No. 190.)

Silica	67.95%
Alumina	20.15
Ferric oxide	1.00
Lime	1.00
Magnesia	tr.
Alkalies	1.87
Ignition	8.00
	99.97
Total fluxes	2.00

There are many points of a desireable nature to be found in this material, viz., its high plasticity, its great density on burning, and its good tensile strength, all of which would combine to make it a ball clay of good quality. The color on burning is not quite as white as could be desired but no doubt washing would improve this.

CHINA CLAY.

TWO MILES N. OF KYMULGA, TALLADEGA CO. (NO. 205.)

A hard white clay, plainly stratified, due to the abundance of many white mica scales arranged parallel with the bedding. It is fine grained with a small amount of fine grit. It slakes very slowly breaking into scaly fragments.

When ground to pass through a 100 mesh sieve it required 18 per cent. of water to mix it up, and give it a mass which was only moderately plastic, owing to the high amount of mica which it contains.

The air shrinkage of the clay when thus mixed is 5 per cent.

When burned to about 2200° F, the color was pure white, and the total shrinkage 8½ per cent., but incipient fusion had not been reached.

At 2350° F, the color was white, and the total shrinkage 11 per cent.

In both cases the bricklets showed a tendency to crack in burning.

Incipient fusion occurred at cone 27 in the Deville furnace, but at cone 30 vitrification was not complete.

If used by itself it would probably not be safe to use the clay in its raw condition above 2250° without developing a yellowish tinge, although this migh not be noticeable when ball clay and quartz and feldspar were mixed.

The mica interfers with the tensile strength just as it did with the plasticity, so that the former did not exceed 15 lbs. to the square inch and varied between that and 12 lbs. per square inch.

The chemical analysis of the material is as follows:

Analysis of China Clay near Kymulga, Talladega Co. (*No.* 205.)

Silica	50.45
Alumina	35.20
Ferric oxide	.80
Lime	.60
Magnesia	.62
Alkalies	——
Ignition	12.40
	100.07
Total fluxes	2.02

The clay would no doubt work for the manufacture of white tile; or white earthenware, but could not be used for porcelain without being washed.

(No. B. S.)

CHINA CLAY,

EUREKA MINE, DEKALB CO.

It is whitish clay, with little or no grit, and of remarkable purity. In water it breaks up slowly to small grains.

It took 33 per cent. of water to temper it, and gave a lean mass, which shrunk 2 per cent. in drying, and an additional 6 per cent. in burning, giving a total shrinkage of 8 per cent. Air dried briquettes of the clay had an average tensile strength of 25 pounds per square inch, with a maximum of 27 pounds.

Incipient fusion occurs at 2300° F. vitrification at 2500° F., and viscosity above 2700° F.

The clay burns to a very white, smooth body.

An analysis of the clay gave the following results:

Analysis of China Clay, Eureka Mines, DeKalb Co. (No. B S.)

Silica	47.00
Alumina	38.75
Water	12.94
Clay base	98.69
Ferric oxide	.95
Lime	.70
Magnesia	tr
Alkalies	tr
	100.38
Total fluxes	1.65
Specific gravity	2.34

This clay approaches closely to kaolinite in its composition.

(No. 128.)

CHINA CLAY,

H. H. GRIFFIN, EUREKA MINE.

This is a white clay, which represents the best quality obtained in the mines of H. H. Griffin, four miles northeast of Valley Head.

It is a very gritty, lean clay, which took 38.50 per cent. of water to work it up.

The air shrinkage was $3\frac{1}{2}$ per cent., and at 2250° F. it had only shrunk 6 per cent., and barely showed signs of incipient fusion. Vitrification takes place at 2800° F. The analysis of a clay from this locality, from what is known as the Eureka Mine, and made by A. T. Brainard, was kindly furnished to the writer by Mr. Griffin. It is as follows:

Analysis of China Clay, Eureka Mines, DeKalb Co.

Silica 5	53.7300
Alumina	34.5390
Ferrous oxide	.8530
Lime	.4144
Magnesia	.3420
Alkalies	tr
Sulphuric acid	.2018
Phosphoric acid	.0522
Ignition	12.28
	102.4124
Total fluxes	1.609

The following analysis of sample collected by writer from the mines in 1897, gave the following:

Analysis of China Clay, Eureka Mines, DeKalb Co. (*No.* 128.)

Silica	82.11
Alumina	11.41
Ferric oxide	1.40
Lime	tr
Magnesia	.661
Alkalies	1.80
Ignition	4.001
	4.001
	101.882
Total fluxes	3.86

The rational analysis gave.

Clay substance	20.20
Quartz	69.20
Feldspar	10.40
	99.80

The feldspar percentage influences the fusibility of this clay, and the difference in the two quantitative analyses is due to the latter having been made on an unwashed sample.

(No. 214.)

CHINA CLAY,

FROM F. Y. ANDERSON, NEAR FORT PAYNE, DEKALB CO.

This clay is rather sandy in its nature, unless ground extremely fine, the granular character being due partly to the halloysite which it contains.

It slakes very slowly and incompletely, and took in its air dried condition 30 per cent. of water to work it up.

The air shrinkage of the bricklets was 7 per cent. At cone 27 in the Deville furance, it was white and showed traces of incipient fusion. At about 2350° F., it burned white without a trace of yellowish color, and with a total shrinkage of 11 per cent.

It is evident that this material could be used in the manufacture of white ware. It would, however, take much grinding to develop its plasticity fully.

The tensile strength was from 60 to 65 pounds per square inch when the material was ground to 60 mesh, and the briquettes are very constant in strength. With finer grinding the tensile strength would very probably increase.

The chemical analysis yielded:

Analysis of China Clay, F. Y. Anderson, DeKalb Co. (No. 214.)

Silica	53.50
Alumina	34.45
Ferric oxide	.21
Lime	.30
Magnesia	trace
Alkalies	.21
Ignition	13.20
	101.87
Total fluxes	.72

(No. 38 S.)

CHINA CLAY.

J. J. MITCHELLS, CHALK BLUFF, MARION CO.

Pure white, fine grained clay, brittle when dry, and with conchoidal fracture. It slakes easily in water, all of it passing through a 60 mesh sieve and most of it through a 100 mesh one.

The clay ground to pass through a 30 mesh sieve, and mixed with 24 per cent. of water, gave a lean mass whose air shrinkage was 4 per cent. and an additional shrinkage of 3 per cent. took place in burning, giving a total of 7 per cent.

Air dried briquettes of the clay gave the usual low tensile strength of kaolin, the average being 15 pounds per square inch, with a maximum of 17 pounds per square inch.

Incipient fusion occurs at 2300° F., vitrification at 2600° F., annd viscosity at 2700° F.

The clay burns to a clear white body. Its composition is as follows: (No. 1 being by H. Ries and No. 2 by W. B. Phillips. No. 3 is the composition of pure kaolin given for comparison.)

Analyses of China Clay, Chalk Bluff, Marion Co.

	1	2	3
Silica	47.25	47.20	46.30
Alumina	36.50	37.76	39.80
Water	13.35	14.24	13.90
Ferric oxide	2.56	tr	
Lime	tr	tr	
Magnesia	tr	tr	
Moisture	.50	tr	
	100.16	99.20	100.00

Total fluxes (!)	2.56
Specific gravity	2.44

(No. 85.)

CHINA CLAY.

CHALK BLUFF, MARION CO.

This clay which occurs on the property of Mrs. Nelson is a smooth, white, fine grained clay with a conchoidal fracture. It slakes easily into angular grains. It is very lean, and requires 33 per cent. of water to mix it up. The tensile strength is also very low, being only 15 pounds per square inch. The air shrinkage is 4 er cent.

At 2200° Fahr. the total shrinkage was 10 per cent. At. 2350°, it was 15 per cent., and the bricklet incipiently fused, with a yellowish white color.

At 2500°, the total shrinkage was 18 per cent. The color was yellow. Vitrificaton occurred at 2700° F.

In the Deville furnace, at cone 27, the clay was nearly viscous.

No analysis was made of this clay.

(No. 37 S.)

CHINA CLAY.

BRIGGS FREDERICK, NEAR CHALK BLUFF, MARION CO.

This was a fine grained clay, 90 per cent. of it passing through a 60 mesh sieve. The clay took 25 pei cent. of water to be worked up, and even then was lean and granular, fine grinding being necessary to develop proper plasticity.

The air shrinkage was 2½ per cent. and the fire shrinkage was the same, giving a total shrinkage of 5 per cent. in the case of a sample ground to pass through a 30 mesh sieve.

The air dried briquettes showed an average tensile strength of 14 pounds per square inch, and a maximum of 16 pounds.

Incipient fusion occurs at 2300° F., vitrification at 2500° F., and viscosity above 2700° F. The clay burns to a white but somewhat porous body.

Its composition is as follows:

Analysis of China Clay, Briggs Frederick, Marion Co. (No. 37, S.)

Silica	65.49
Alumina	24.84
Water	7.50
Ferric oxide	tr.
Lime	1.26
Magnesia	tr.
Alkalies	tr.
Moisture	.30
	99.37
Total fluxes	1.26
Specific gravity	1.76

This clay is very low in iron, and the small percentage of lime is no detriment.

(No. 36 S.)

CHINA CLAY.

PEARCE'S MILL, MARION CO.

A hard, porous, coarse grained, gritty clay, which in water breaks up slowly into angular fragments, each of which in turn keeps splitting.

Twenty-five per cent. of water was required to work it up, but it is very lean. The air shrinkage was 3 per cent. and an additional 12 per cent. in burning, making a total of 15 per cent.

The tensile strength of air dried briquettes varied on the average 12-14 pounds per square inch with a maximum of 20 pounds per square inch.

Incipient fusion occurred at 2300° F., vitrification at 2500° F., and viscosity at over 2700° F.

The clay burns at 2300° F. to a very white body.

The analysis of it yielded.

Analysis of China Clay, Pearce's Mill, Marion Co. (No. 36, S.)

Silica (combined)	38.60	
Alumina	32.50	
Water	11.05	
Clay base		82.15
Silica (free)	17.68	
Ferric oxide	.20	
Lime	tr.	
Magnesia	tr.	
Alkalies	tr.	
Moisture	.20	
	100.08	
Total fluxes	.20	
Specific gravity	2.33	

With washing, this clay would probably be well adapted to the manufacture of the highest grades of pottery. It contains less fusible impurities than most of the kaolins used in this country, and the probabilities are that if the deposit were constant in its character it might not require washing.

(No. 56 S.)

CHINA CLAY.

PEGRAM, COLBERT CO.

A fine grained, whitish, homogeneous but not very dense clay with a smooth fracture.

In water it slakes slowly to grains under a sixtieth of an inch (1-60 in.)

Thirty per cent. of water was required to make a workable mass, which to the feel was quite lean. The air shrinkage of bricklets made from it was 7 per

cent., and 4 per cent. in burning, making a total of 11 per cent.

The tensile serength of the air dried briquette was quite low, being 40 pounds per square inch on the average, with a maximum of 53 pounds per square inch.

Incipient fusion occurs at 2200° F., vitrification at 2400° F., and viscosity at 2600° F.

The clay burns to a white body which is hard and dense, the following is the analysis of the clay.

Analysis of China Clay, Pegram, Colbert Co. (*No.* 56, S.)

Total Silica	64.90
Alumina	25.25
Water	8.00
Moisture	.90
Ferric oxide	trace
Lime	trace
Magnesia	trace
	99.05
Free silica	34.40
Specific gravity	2.35

The material is to be looked upon as a white-ware clay of good grade, from which the sand could be removed by washing if necessary. There are practically no published analysis with which this agrees very closely, but a comparion is not necessary as the purity of the material is self evident.

FIRE CLAYS

The term fire-clay is applied to those clays which will resist a high temperature without fusing.

Fire clays are of two kinds, flint clays and plastic clays.

The flint clays generally approach kaolinite in composition, but have no plasticity, or at the most a very

slight degree of it. They are generally of a highly refractory nature, their fusing point being commonly above 2700° F. and their shrinkage in drying and burning is extremely low. They therefore make an excellent grog to add to the more plastic clays for the purpose of reducing their shrinkage. Flint clays have thus far not been found in Alabama, except in Conecuh, Choctaw, Washington, Clarke and Monroe counties.

Plastic fire clays are widely distributed and are especially abundant in the Coal Measures of many states, but they may also ocsur in the Cretaceous and Tertiary formations. Those of the Carboniferous are often of a shaly nature and to be ground before their plasticity can be brought forth.

The requisite qualities of a fire clay vary somewhat according to the use to which it is to be put, and it is still a disputed point, just what temperature the fusion point of a clay should exceed in order to be classed as a refractory one. As it now stands, many American clays are unfortunately and erroneously classed as fire clays which can not withstand a temerature of more than 2300° or 2400° F. Many of the New Jersey fire clays require a temperature of from 2500° to 2600° F. to burn them.* The fire clays of Missouri fuse at from 2400° to above 2700°.

No arbitrary line can be drawn between refractory and semi-refractory clays, but if such a division were made it would seem advisable not to call any clay refractory which is affected by a temperature of less than 2700° F. Many of the Alabama fire clays conform to this definition.

While it is desirable that fire clays should posses good plasticity and low shrinkage, the main point is their refractoriness. It may be said in general that

the fusible impurities of a fire clay should not exceed 3½ or 4 per cent., but these limits may be extended somewhat in either direction depending upon the nature of the flux and whether the clay is fine or coarse grained.

The shrinkage of a fire clay in burning may often be counteracted by the addition of grog, i. e. sand, ground fire brick, or similar substances.Fire clays which are too fat and plastic are likely to crack in burning, but at the same time they give a dense body. It is desirable that any burned clay or grog which is mixed with the raw material should have previously been burned as dense as possible. Fine grains of powdered grog permits the brick to shrink more in burning than the course and bricks with the latter generally stand changes of temperature better. Next to burned clay, quartz is perhaps the most important grog, and flint clay serves a similar purpose.

If a fire brick made only of clay and clay grogs still shrinks when placed in the furnace, sharp quartz grains should be added, as they have a tendency to expand on repeated heating. Fine grained quartz sand should in no case be added if the brick is to be exposed to high temperatures, for in such cases it tends to flux the clay in burning, furthermore the addition of coarse quartz must also be within limits for if in too large quantity the quartz grains loosen the brick by their expansion. A good fire brick is sometimes made by mixing a non-plastic refractory clay with a very plastic dense burning, semi-refractory one.

No fixed rules can be laid down to govern the selection and valuation of a fire clay for the reason that the use to which it is to be put determines its qualities to a large extent. All fire clays should

resist a high temperature. Some are used in situations requiring resistance to heat and these must be coarse grained. Others when burned into bricks must resist corrosion and consequently should burn to a dense product, as in the case of glass pot clays.

Fire bricks.—These should show a resistance to high temperatures, and also the fluxing action of ashes from the fuel, which contain carbonates, sulphates, and phosphates of the alkalies and alkaline earths. In addition they should withstand the corrosive action of fused metallic slags, alkalies, and glasses.

The density of the fire brick is often of great importance especially where it is to resist the corrosive action of molten material. The fat plastic clays are those which usually burn to the most dense body, but in doing so they frequently crack to such an extent that grog has to be added to them.

Porous, coarse grained bricks on the other hand stand heat better.

The fire-clays below reported on come from four geological horizons, viz., (1) The Cambrian and Silurian limestone formations of the Coosa Valley region; No. 191 from Peaceburg, Calhoun county; No. 127 Stevens, from Oxanna, Calhoun Co.; the refractory clays of Rock Run, Cherokee Co.; and the bauxites from the same locality. (2) The cherty limestones of the lower Subcarboniferous formation of Wills' Valley; No. 117 and 116 from the Montague mines, and No. 119 from near Valley Head in DeKalb county. (3) The Tuscaloosa formation of the lower Cretaceous, No. 112 from Bibbville, and No. 111 from Woodstock in Bibb county; No. B from near Hull's Station, and No. 118 from near Tuscaloosa in Tuscaloosa county; Nos. 1 and 2 from Pearce's Mills

in Marion county and No. 57 S. from Pegram in Colbert county. (4) The lower Tertiary formation, No. C S from Choctaw county. Of these only the clays from Bibbville and Woodstock have been regularly mined.

(No. 191.)

FIRE CLAY.

FROM PEACEBURG, NEAR ANNISTON.

A grayish white clay of very fine grain, and containing a noticeable amount of very fine mica scales. In water it slakes moderately fast.

Twenty-five per cent. of water was required to work it up, and the resulting mass was rather lean, and had a somewhat flaky structure, which interferred with the development of the plasticity.

Bricklets made from the mixture had air shrinkage of 5 per cent.

When burned to about 2100° F. the total shrinkage amounted to 10 per cent, the clay was white with a faint tinge of yellow and the brick was still very porous. At about 2250° F. incipient fusion has barely been reached, w'th a total shrinkage of 13 per cent., the color being white tinged to a noticeable extent with yellow. At about 2300° F. the bricklet burned cream color, was incipiently fused, and the total shrinkage amounted to 15 per cent.

In the Deville furnace the clay vitrified at cone 30, but did not lose its shape.

Owing to the leanness the tensile strength was very low, and ranged from 20 to 25 pounds per square inch.

The chemical analysis of the clay gave:

Analysis of fire clay, Peaceburg. Calhoun Co. (No. 91.)

Silica	51.90
Alumina	35.00
Ferric oxide	.99
Lime	.23
Magnesia	.10
Alkalies	.55
Ignition	11.30
	99.87
Total fluxes	1.87

The low plasticity of this clay would probably interfere with its being used alone, but owing to its refractory nature and the light color developed in burning it could no doubt find use as an ingredient of other clay mixtures.

(No. 127 of Mr. Stevens.)

FIRE CLAY.

FROM OXANNA, CALHOUN COUNTY.

This is a coarse and sandy clay, which mixes up to a lean mass with only 16 per cent. of water. The tensile strength is very low, being on the average of 9 to 10 pounds per square inch, and the air shrinkage is 2 per cent.

The following is the behavior of the clay at successively higher temperatures.

At 2200° F. the color was grey white.

At 2250° F. shrinkage 3 per cent., color buff.

At 2300° F. shrinkage and color same.

At 2400° F. shrinkage 3 per cent., color buff, showing specks of ferric oxide.

At 2500° F. the shrinkage was only 2 per cent., having undergone a slight swelling owing to the very high quartz percentage. Incipient fusion had not

occurred up to this point. The following is the analysis of this clay.

Analysis of Fire Clay, Oxanna, Calhoun Co. (No. 127, Stevens).

Silica	84.21
Alumina	9.75
Ferric oxide	.69
Lime	.70
Magnesia	.14
Ignition	4.10
	99.59
Total fluxes	1.53

REFRACTORY CLAYS

OF ROCK RUN, CHEROKEE COUNTY.

Associated with the bauxites at Rock Run are a number of clays, most of them of fine grained texture, but some showing small quantities of grit, and which vary in color from pure white to mottled ones, which at times contain an appreciable percentage of sand. Samples of these clays from six different locations have been tested, they come from what are known as the Dykes old Iron Ore Mine and the Dykes Bauxite Mine, on the property of the Rock Run Iron Mining Co. in Cherokee county.

No. 1. is on the north side of the iron mine reservation at the extreme western end; No. 2 and 3 are from the same side of the pit, but at points 125 and 200 feet farther east respectively; No. 4 is from the western end of the Bauxite pit and on the north side of the entrance to it; No. 5 is on the north side of the same pit and No. 6 at the eastern end of it.

Nos. 1, 2, 3, each show a face 15 to 20 feet in height, and are of probably greater thickness. No. 4 is looked upon as a very low grade of bauxite.

The following tests mere made upon these samples:

No. 1. This is a fine grained white clay, with a splintery fracture, showing iron stains along the joint cracks and other planes or fracture, but none in the interior of the mass. It slakes quickly but not completely into angular fragments. In mixing it up, 32 per cent. of water was required and the resulting mass was lean and granular. It had been previously passed through a 30 mesh sieve, and it ground to a finer mesh would, no doubt, be more plastic. The lean granular character gives it a very low tensile strength amounting to not over 6 pounds.

The air shrinkage of the clay was 4 per cent. at about 2200½ F., the total shrinkage was 9 per cent; and at about 2300°, 18 pr cent., at about 2500°, the total shrinkage was 21.50 per cent, and the color of the burned bricklet was still white.

When tested in the Deville furnace at cone 30 the form of the clay still remained sharp, and it was white in color, but showed signs of incipient fusion.

The composition of the clay is as follows:

Analysis of Fire Clay, Rock Run, Cherokee Co. (No. 1.)

Silica	47.60
Alumina	36.70
Ferric oxide	1.10
Lime	1.30
Magnesia	trace
Alkalies	trace
Ignition	14.20
	100.90
Total fluxes	2.40

These tests indicate that the clay is quite refractory, and its burning to a white color would permit its being used for products having a white body. The high shrinkage is somewhat against it, but this could

be counteracted to a large extent by the addition of quartz and it would also be necessary to mix it with some plastic clay, if it was to be molded when wet.

No. 2. This is similar to No. 1 in its color and texture. It is however much more plastic than the other although it only required 31.25 per cent. of water to mix it, the tensile strength however is very low, and in this case bears no relation to the plasticity, the air shrinkage of the clay is 3 per cent; at about 2200° F., the total shrinkage was 10 per cent. and the bricklet was still absorbent although incipient fusion had just begun, while the color was yellowish white; at about 2250° F., the total shrinkage was 14 per cent., the bricklets had an absorption of about 5.7 per cent. and the color still a yellowish white. At about 2300° F. the total shrinkage was 16 per cent., the absorption only 2 per cent. while its color was a very faint yellowish gray; the total shrinkage was 17 per cent. at 2400° F., and the bricklet which appeared nearly vitrified, was gray in color.

In the Deville furnace at cone 30, the form of the clay was still perfectly sharp, and while it was thoroughly vitrified it showed no evidence of becoming viscous.

The rational composition of the clay was:

Clay substance	94.54
Quarts	5.80
Ferric oxide	.26

No. 3. This is likewise a white clay but one containing much fine grit, not very porous, and slaking quickly to a powder. It is also a very plastic clay, and took 36.50 per cent. of water to work up, but the tensile strength again is very low, being not over 5 pounds. The air shrinkage was 3 per cent.; at about

2200° F., the total shrinkage was 12 per cent., and the bricklet white, with an absorption of 7.20 per cent. At about 2250° F. the total shrinkage was 13 per cent. and the bricklet, which had an absorption of 6.3 per cent. was white with a very faint tinge of yellow. At about 2300° F., the total shrinkage amounts to 15.5 per cent., the color of the bricklet white with a mere shade of gray, and the absorption of it had decreased to 1.3 per cent. The total shrinkage at about 2500° F. was 17.5 per cent. and vitrification had occurred, the bricklet being whitish in color.

In the Deville furnace at cone 30, the form of the clay pyramid was still erect, and while the clay was thoroughly vitrified the angles were still sharp and color whitish. The composition is:

Analysis of Fire Clay, Rock Run, Cherokee Co. (No. 3).

Silica	72.20
Alumina	22.04
Ferric oxide	.16
Lime	.50
Magnesia	.40
Alkalies	.60
Ignition	5.80
	101.70
Sand	34.52
Total fluxes	1.66

No. 4. This clay as has already been stated is a low grade bauxite, it is white in color with a slight yellowish tinge and portions of it show a pisolitic structure. It slakes quickly. 31.35 per cent. of water were required to work it up and even then the mud was extremely granular and very lean, and the air dried briquetts had a tensile strength of only 5 pounds. The air shrinkage was 5 per cent. At 2250° F. the total shrinkage was 14 per cent., the bricklets

very porous, of a white color with a mere tinge of yellow. At 2400° F. the total shrinkage was 15 per cent.

In the Deville furnace at cone 27, the clay still remained entirely unaffected, but the color was grayish, and the total shrinkage up to this point amounted to 26 per cent.

The composition of the clay is:

Analysis of Fire Clay, Rock Run, Cherokee Co., No. 4.

Silica	17.70
Alumina	59.46
Ferric oxide	.36
Ignition	22.06
	99.58
Total fluxes	.36

No. 5. This is a soft whitish, easy slaking clay, but a very porous one which absorbs 40 per cent. of water in working it up, and even then gave a very lean mass, whose tensile strength, when made into briquettes and air dried, was only 5 pounds per square inch. The air shrinkage is 4 per cent, and at about 2250° F. the total shrinkage was 17 per cent., but the bricklets, whose color was yellow, were still very porous and could be scratched by a knife without much difficulty; at 2400° F., the shrinkage showed a total of 22 per cent. and incipient fusion began; at 2500° F., the total shrinkage was 23 per cent., the brick was still porous and faintly yellowish white.

In the Deville furnace at cone 30, the clay had burned dense, was incipiently fused, but otherwise unaffected, its color was a grayish white and the total shrinkage amounted to 34 per cent., which is really not surprising when we consider the high amount of

combined water that the clay shows, for it is evidently a low grade bauxite like the preceding one.

The composition is:

Analysis of Fire Clay, Rock Run, Cherokee Co., No. 5.

Silica	31.20
Alumina	44.28
Ferric oxide	1.45
Lime	1.00
Magnesia	.20
Ignition	22.60
	100.73
Total fluxes	2.65

This clay is evidently a mixture of clay and bauxite, as can be seen from the high shrinkage and large percentage of combined water.

No. 6. The color of this clay is yellow, and it is fine grained but not hard, and shows numerous slickenside surfaces. In slaking it breaks up easily but slakes completely to powder only after long immersion in water. The clay is very lean, and requires as much water as the preceding to mix it up; the tensile strength is also very low being under 5 pounds. The air shrinkage is 2 per cent., the total shrinkage at 2200° F. is 8 per cent.; at 2250° F. it is 12 per cent.; at 2400° F. it is 13 per cent; at 3500° F. it is 15 per cent.; at 2600° F. it is 20 per cent., and the bricklet was still very absorbent.

In the Deville furnace at cone 27, the clay had burned dense, but still preserved its form with sharp edges and showed a total shrinkage up to this point of 35 per cent.

The composition of the clay is as follows:

Analysis of Fire Clay, Rock Run, Cherokee Co., No. 6.

Silica	34.60
Alumina	45.80
Ferric oxide	.52
Ignition	20.00
	100.92
Total fluxes	.52

REFACTORY BAUXITES.

ROCK RUN, CHEROKEE COUNTY.

In addition to these bauxitic clays, six samples of bauxite were also tested chiefly to determine their refractoriness and their shrinkage in burning, the method adopted with most of them being to grind up the specimen, so that it would pass through either a 20 or a 30 mesh sieve, the particles which did not pass through being also retained. Several mixtures of the coarse and fine material were made. The mass produced in every instance by mixing it with water was extremely low in its plasticity, and lacked greatly in tensile strength, the latter in every instance being not more than 2 or 3 pounds per square inch.

In many cases, the bauxite showed so little tenacity and was so little affected by the heat that bricks which had been burned at a temperature of 2600° F. were easily rubbed apart with the fingers. Another point to be noticed is the enormous shrinkage which all of the specimens exhibited, the air shrinkage, however, being very low.

No. 1. This was powdered and passed through a 30-mesh sieve, and on working up gave a very lean mass, which required 24 per cent. of water. The air shrinkage was 3 per cent. and at 2400° F. the total shrinkage was 11 per cent, while the bricklet was very porous and white. At 2500° F. the bricklet had not shrunk any more but the color had become reddish.

In the Deville furnace at cone 30, the bauxite was totally unaffected although it had become somewhat dense, and showed a shrinkage of 23 per cent. The composition was:

Analysis of Bauxite, Rock Run, Cherokee Co., No. 1.

Silica	8.80
Alumina	61.64
Ferric oxide	1.10
Lime	trace
Magnesia	trace
Ignition	29.97
	100.51

No. 2. Two mixtures were made of this, viz: *a.* which was 50 per cent. of grains between 15 and 20-mesh, and 50 per cent. smaller than 20-mesh. The bricklet made from this showed a total shrinkage of 12 per cent. at 2400° F., while at 2600° F., the shrinkage was 14 per cent. and the bricklet was so friable that it could be easily rubbed apart.

b. The bauxite was ground and passed through a 30-mesh sieve. In this condition it took 25 per cent. of water to mix it up, and made a very lean paste. The shrinkage of the bricklets made from this was about 10 per cent at 2250° F., they were very porous, soft, and of a slight yellowish tint; at about 2400° F. the total shrinkage was 15 per cent. and at 2600° F. amounted to 17 per cent., but the bricklet was still scratched by a knife without much difficulty. In the Deville furnace the bauxite was still uneffected at cone 30, but showed a total shrinkage of 27 per cent.

Its composition is:

Analysis of Bauxite, Rock Run, Cherokee Co., No. 2.

Silica	18.30
Alumina	54.39
Ferric oxide	1.36
Ignition	27.60
	101.65

72. (No. 3.) Ground to pass through a 20-mesh sieve, it gave a very lean mass on the additcn of 25 per cent. of water.

The air shrinkage was 2 per cent.

At 2400° F. the brick was very loose and crumbly.

At 2500° F. shrinkage 11 per cent.

At 2600° F. shrinkage 18 per cent.

At 3150° F. shrinkage 22 per cent. Totally unaffected.

Analysis of Bauxite, Rock Run, Cherokee Co., No. 3.

Silica	3.30
Alumina	69.06
Ferric oxide	.20
Lime	....
Water	28.10
	100.66

48. (No. 4.) Three mixtures were made up as follows:

a. 33 per cent. smaller than 20-mesh.
67 per cent. 10-20 mesh.

b. Under 30 mesh.

c. Under 20-mesh.

All three gave lean mixtures.

a. Took 23 per cent. water to work it up.

b. Took 20 per cent. water to work it up.

c. Took 24 per cent. water to work it up.

The air shrinkage was *b.* 2 per cent., *c.* 1 per cent.

At 2400° F. *b* showed 10 per cent. shrinkage and the particles barely colored.

At 2500°F. *b* had shrunk 11 per cent. and held; *c* 13 per cent. but was very loose.

At 2600° F. *b.* and *c.* had both shrunk 13 per cent. but could still be scratched by the knife.

At 3000° F. the bauxite was unaffected, and showed a total shrinkage of 17 per cent.

Analysis of Bauxite, Rock Run, Cherokee Co., No. 4.

Silica	3.30
Alumina	66.70
Ferric oxide	.10
Water	31.30
	101.40

49. (No. 5.) Mixtures made were:

a. 35 per cent. 10-20 mesh and 65 per cent. under 20 mesh. Required 18 per cent. of water to work up.

b. under 30-mesh. Required 20 per cent. of water.

c. under 20-mesh. Required 25 per cent. of water.

The air shrinkage of all was 1 to 2 per cent.

At 2550° F. the shrinkage was 20 per cent.

The bauxite when heated to cone 30 in the Deville furnace, preserved its form and sharp edges, and showed the faintest trace of incipient fusion. It is therefore highly refractory.

Analysis of Bauxite, Rock Run, Cherokee Co., No. 5.

Silica	.28
Alumina	68.14
Ferric oxide	trace
Water	32.60
	101.02

73. (No. 6.) A whitish, claylike bauxite. This took 46 per cent. of water to work it up and gave a fairly plastic mass, but had very little tensile strength.

At 2400° F. the shrinkage was 10 per cent., bricklet still soft enough to be scratched by the nail.

At 2550° F. shrinkage 27 per cent.

At 2600° F. shrinkage 30 per cent., brick resisted scratching by a knife.

At 3100° F. bauxite dense, gray in color, but form perfectly sharp.

Analysis of Bauxite, Rock Run, Cherokee Co., No. 6.

Silica	9.50
Alumina	61.14
Ferric oxide	trace
Lime	trace
Magnesia	trace
Water	31.20
	101.84

The foregoing tests of these bauxites show a high refractoriness, but also a very high shrinkage which increases apparently with the fineness of grain. It is difficult to draw conclusions from six specimens, however, just what the relations of silica, alumina, water and size of grain are which influence the shrinkage.

All of these bauxities would, of course, have to be first calcined if used for refractory purposes; but they could then be mixed with a small amount of plastic clay to serve as binder and would then make a very refractory article. In my report I shall discuss this point.

(No. 117)

FIRE CLAY.

NEAR VALLEY HEAD, DEKALB COUNTY.

The clay mines of the Montagues are situated about two mile up the railroad from Valley Head, and a few hundred feet to the west of the track. Several grades of clay are obtained from the mines, but they are not restricted in any case to certain layers. The following sample tested is what is known at the mines as the first grade, and its refractory character is not by any means low.

The material is a white sandy clay, rather coarse

grained and containing occasional reddish or pinkish stains. There is no mica to be seen in it. It is hard but very porous, and practically does not slake when immersed in water for a long period.

When mixed with 35 per cent. of water it gave a gritty but lean mass, which had an air shrinkage of 4 per cent. In this case it had been ground to pass through a 60-mesh sieve. When ground to pass through a 100 mesh sieve it absorbed the same quantity of water but the plasticity was slightly increased, while the air shrinkage remained about the same.

At 2100° F. the clay burns white; at 2300° F. it is white with a slight tinge of yellow, and at 2350° F. it is the same with the total shrinkage amounting to only 4 per cent. Incipient fusion occurs at 2400° F. and at cone 27 in the Deville furnace the clay vitrified.

The tensile strength is very low, not over 5 or 6 pounds per square inch.

The chemical analysis yielded:

Analysis of Fire Clay, near Valley Head, DeKalb Co. (No. 117).

Silica	82.04
Alumina	12.17
Ferric oxide	trace
Lime	trace
Magnesia	.327
Alkalies	.60
Ignition	4.325
	99.462

Total fluxes	9.27
Specific gravity	2.38

The rational composition is:

Clay substance	31.10
Quartz	64.80
Feldspar	3.90
	99.90

(No. 116.)

FIRE CLAY.

NEAR VALLEY HEAD, DEKALB COUNTY.

Occurring in the same quarry is what is known as the second grade of fireclay. This is a fine grained yellowish gray clay containing much fine grit. It slakes quite quickly when thrown in water, and when worked up with 39 per cent. of water gave quite a plastic mass. The air shrinkage of the bricklets amounted to 8 per cent. which is greater than that of the first grade, which was also less plastic. The tensile strength seems to have increased with the plasticity for it amounted to 20 pounds per square inch. When burned to 2350° F. the total shrinkage was 17 per cent. and incipient fusion took place, while vitrification occurred at 2700° F. and at cone 27 in the Deville furnace the clay fused but did not run. It will be thus seen that it is less refractory than the so called first grade, which only vitrified at this latter temperature. Both are to be classed as fireclays however. Up to incipient fusion, the clay remains white, but above that it begins to show a yellowish tint due to the presence of iron oxide in the clay.

The chemical composition of the clay is:

Analysis of Fire Clay, near Valley Head, DeKalb Co. (*No.* 116).

Silica	79.80
Alumina	11.75
Ferric oxide	1.75
Lime	.75
Magnesia	trace
Alkalies	1.50
Water	4.11
	99.16
Total fluxes	3.50
Specific gravity	2.37

The rational analysis of the clay gave:

Clay substance	31.20
Quarts	58.00
Feldspar	10.80
	100.00

(No. 119).

FIRE CLAY,

FROM NEAR FORT PAYNE, DEKALB COUNTY.

Major F. Y. Anderson has made several openings to the west of the Alabama Great Southern Railroad at several points between Valley Head and Fort Payne.

The clay found in these pits is in appearance not unlike that which is found in the mines of Montague and Griffin to the northward. The different grades are recognized.

The second grade, as it is called, No. 119, is a somewhat soft, gritty, lean clay, of a yellowish color, due to the numerous stains of iron oxide, and when thrown into the water slakes slowly to a powder.

Forty per cent. of water gave a lean mass, and the air shrinkage of the bricklet made from this was 8 per cent. Incipient fusion occurs at 2300° F., the total shrinkage at this point being 14 per cent., and the bricklet is yellowish white. When heated to cone 27 in the Deville furnace the clay showed vitrification. While it is fairly refractory in its nature, at the same time, owing to the yellowish tint developed in burning, it would not, in its natural condition, do for the manufacture of white ware. It is possible, however, that washing might eliminate some of the undesirable impurities.

The chemical composition is as follows:

Analysis of Fire Clay, near Fort Payne, DeKalb Co. (*No.* 119).

Silica	66.25
Alumina	22.90
Ferric oxide	1.60
Lime	trace
Magnesia	trace
Alkalies	.75
Ignition	9.05
	100.55
Total fluxes	2.35
Specific gravity	2.28

The rational analysis yielded:

Clay substance	40.70
Quartz	47.90
Feldspar	11.20
	99.80

(No. 112).

FIRE CLAY,

FROM BIBBVILLE, BIBB COUNTY.

This is one of the clays used by the fire brick works at Bessemer, near Birmingham. For use it is mixed with several other clays.

The material itself, however, is a very sandy clay, with much coarse grit and appreciable quantity of mica. It is also abundantly stained with limonite in places. When thrown into water it slakes fairly fast and falls to powder. It is quite a plastic clay, but in working it up into a plastic mass it took only 22.6 per cent. of water.

The air shrinkage amounts to 6½ per cent. At about 2200° F. the clay burns creamy white, and shows a total linear shrinkage of 9 per cent. While at about 2300° F. incipient fusion is reached, with the shrinkage the same, and the color buff. Vitrification

was not attained until the clay was heated to cone 27 in the Devilie furnace, and ever at this temperature the clay cone remained still perfectly sharp.

The tensile strength is moderate, ranging from 75 to 110 pounds per square inch, with an average of 102 pounds per square inch.

The analysis of this fire clay is:

Analysis of Fire Clay, Bibbville, Bibb Co. (*No.* 112).

Silica	74.25
Alumina	17.25
Ferric oxide	1.19
Lime	.40
Magnesia	tr.
Alkalies	.52
Ignition	6.30
	99.39
Total fluxes	2.11
Specific gravity	2.44

(No. 111).

FIRE CLAY,

ELGIN PROPERTY, NEAR WOODSTOCK, BIBB COUNTY.

A sandy, micaceous clay, of yellowish color, which breaks up slowly, but completely, when immersed in water. This needed 23 per cent. of water to work it up, and gave a moderately plastic mass. The air shrinkage amounted to 7 per cent. In burning the bricklets incipient fusion occurred at 2150° F., with a total shrinkage of 14 per cent., and the color of the clay light buff. At about 2300° F. the shrinkage was 16 per cent., and the color yellow. Vitrification took place at 2350° F., and at this point the shrinkage had incresaed to 18 per cent., while the color had changed to grayish. Fusion tock place at 2900° F.

The tensile strength is moderate, and varied from 100 to 110 pounds per square inch.

The ultimate composition is:

Analysis of Fire Clay, Woodstock, Bibb Co. (No. 111).

Silica	65.82
Alumina	24.58
Ferric oxide	1.25
Lime	——
Magnesia	tr.
Alkalies	.60
Ignition	8.165
	100.415
Total fluxes	1.85
Specific gravity	2.40

The rational analysis gave:

Clay substance	62.90
Feldspar, Quartz	37.00
	99.90

(No. B).

FIRE CLAY,

AUXFORD'S, NEAR HULL'S STATION, TUSCALOOSA CO.

This is a sandy micaceous gray clay, with a slightly reddish tinge, which crumbles to pieces very quickly when immersed in water. When worked up it gives quite a plastic mass, and requires 33 per cent. of water to accomplish it.

The air shrinkage is from 9 to 10 per cent., and at 2000° F. the total shrinkage was only 12 per cent. At this latter temperature the bricklet was hard, grayish red in color, but still somewhat absorbent, while at about 2200° F. vitrification occurred, with a total shrinkage of 14 per cent. The viscosity occurred at

2500° F. The average tensile strength of the bricklet was 155 pounds per square inch, with a minimum of 140 pounds and a maximum of 168 pounds, which is very good.

The composition of the clay is as follows:

Analysis of Fire Clay, Hull's Station, Tuscaloosa Co. (No. B.)

Silica	61.25
Alumina	25.60
Ferric oxide	2.10
Lime	.25
Magnesia	.82
Alkalies	1.35
Ignition	8.10
	99.47
Total fluxes	4.52

(No. 118).

FIRE CLAY,

J. C. BEAN, TUSCALOOSA COUNTY.

It is a fine grained clay, with very little grit, and of homogeneous structure. When immersed in water it slakes with extreme slowness. The addition of 36 per cent. of water to the clay gives a very plastic mass and the bricklets made from this had an air shrinkage of 12 per cent.

When burned to 2200° F. the total shrinkage amounted to 18 per cent., the bricklet was grayish red in color, and very dense, incipient fusion having occurred. When heated to cone 27 in the Deville furnace it only vitrified.

The burning dense of this clay at such a temperature, and the great difference in temperature between the points of incipient sintering and vitrification are

worthy of notice, and show it to possess character closely resembling those of many glass pot clays.

The composition of this clay is as follows:

Analysis of Fire Clay, Tuscaloosa Co. (No. 118).

Silica	58.13
Alumina	24.68
Ferric oxide	3.85
Lime	.15
Magnesia	.32
Alkalies	1.78
Ignition	11.78
	100.51
Total fluxes	5.92

The rational composition is:

Clay substance	60.85
Quartz	23.35
Feldspar	15.80
	100.00

Glass pot clays vary in chemical composition, and it is really the physical behavior of the material which it is of importance to know. At the same time the analyses of several other glass pot clays are given below for comparison.

Analysis of Glass Pot Clays

No. 1.

Silica	64.89
Alumina	24.08
Ferric oxide	.29
Lime	.41
Magnesia	.19
Potash	.87
Soda	.16
Ignition	9.29

No. 2.

Silica	55.61
Alumina	27.36
Ferric oxide	2.73
Lime	.87
Magnesia	.07
Alkalies	.71
Titanic oxide	1.36
Sulphuric acid*	.51
Moisture	2.26
Ignition	11.13
*Sulphur	.25

No. 1 is from Layton Station, Pa. (1897 Report Pennsylvania State College, p. 90, T. C. Hopkins).

No. 2, St. Louis, Mo., Washed pot clay (Missouri Geological Survey Report, Vol. XI, p. 568.)

(No. 1).

FIRE CLAY,

PEARCE'S MILLS, MARION COUNTY.

This clay forms a bed from four to six feet thick in the ravine to the east of the mill. It is a hard rock-like material, and when mined has more the appearance of a white argillaceous sandstone than a clay. It is very hard, and when thrown into water practically does not slake at all, but it is very porous. When ground to 30 mesh and mixed with water it is very lean, but grinding it to 80 mesh increases the plasticity. In this latter condition it required 37 per cent. of water to work it up. The air shrinkage was 4 per cent., whereas when burned to 2100° F. it was 5 per cent., and at 2200° F. the total shrinkage was 7½ per cent., the color of the bricklet being still white like the original clay, but the porosity great. At about 2300° F. the bricklet developed a slightly grayish tint, and at 2400° the color was the same, but the

total shrinkage 10 per cent. Incipient fusion did not occur until heated to cone 27 in the Deville furnace. This is a very refractory clay, and one that has a comparatively low shrinkage, due to the large amount of silica in its composition.

Vitrification occurs at cone 30 and viscosity at cone 33 in the Deville furnace.

The composition of this clay is:

Analysis of Fire Clay, Pearce's Mill, Marion Co. (No. 1).

Silica	52.95
Alumina	35.10
Ferric oxide	.80
Lime	tr.
Magnesia	tr.
Alkalies	.93
Ignition	11.40
	101.18
Total fluxes	1.73

No. 2).

FIRE CLAY,

PEARCE'S MILLS, MARION COUNTY.

This sample is from a second opening which closely adjoins Pearce's Store, and like the other occurrence in this vicinity, it is very gritty, being even more so than the first, and while the material is very porous, at the same time it slakes very slowly, falling finally to a powdery mass. The fracture of the dry material is hard and angular, the air shrinkage is very low, amounting to only 2 per cent., in the case of sample which had passed through a 30-mesh sieve.

At 2350° F. the shrinkage is only 6 per cent., and the bricklet was creamy white in color, but still very absorbent. In the Deville furnace incipient fusion

occurs at cone 27; vitrification at cone 32 and viscosity at cone 34.

The tensile strength is very low, ranging from 5 to 10 pounds.

The very refractory character of this clay is evident, but its leanness would no doubt necessitate its being mixed with a more plastic clay before it could be used.

(No. 57 S.)

FIRE CLAY,

J. W. WILLIAMS, PEGRAM, COLBERT COUNTY.

A black gritty clay, which slakes easily, considerable organic matter present, but no pyrite or mica noticeable.

It required 28.6 per cent. of water to make a workable mass, which, to the feel, was lean and gritty. Bricklets made of this shrank 10 per cent. in drying and 3 per cent. in burning, giving a total shrinkage of 13 per cent.

The average tensile strength of the air-dried briquettes was 46 pounds per square inch.

Incipient fusion occurs at 2150° F., vitrification at 2350° F., and viscosity at 2500° F.

The clay burns to a white body, slightly tinged with yellow.

The following is its chemical composition:

Analysis of Fire Clay, J. W. Williams, Pegram, Colbert Co. (No. 57, S.)

Moisture	1.70	
Silica (total)	80.55,	free sand 70.10
Alumina	10.50	
Ferric oxide	1.53	
Lime	.34	
Magnesia	traces	
Water and organic matter	5.85	
	100.47	
Total fluxes	1.87	

(No. C. S.)

FLINT CLAY,

CHOCTAW COUNTY.

A hard, fine grained, siliceous clay, resembling flint clay in appearance, but containing more silica than such material usually contains. It presents a smooth surface, with conchoidal fracture, and in water practically does not slake at all.

When ground to pass through a 30-mesh sieve it required 15 per cent. of water to make a workable paste and was very lean and granular. The tensile strength was, on the average, 5 pounds per square inch.

The shrinkage in drying was 2 per cent., and at 2300° F. 6 per cent. Incipient fusion occurs at 2300° F., vitrification at 2500° F. and viscosity at 2650° F.

On account of its refractory qualities and low shrinkage, this flinty clay is admirably adapted for admixture with plastic fire clays to serve as grog and prevent undesirable shrinkage. The following two analyses, No. 1, by W. B. Philips, and No. 2, by H. Ries, give the composition of this material:

Analysis of Fire Clay, Choctaw Co. (No. C. S.)

	(1)	(2)
Silica (total)	86.30	85.70
Alumina	5.12	6.15
Ferric oxide	1.60	1.80
Lime	.46	tr.
Water	6.60	7.00
	100.08	100.65
Total fluxes	2.06	1.80
Specify gravity		1.70

*This is a Radiolarion clay, abundant in the Buhrstone division of the Tertiary formation in many localities in Choctaw, Washington, Clarke, Monroe and Conecuh counties. E. A. S.

POTTERY OR STONEWARE CLAYS.

Many clays which are too impure to be used as fire clays are often admirably adapted for pottery purposes. In fact stone ware clays are often somewhat intermediate in their nature between fire clays and pipe clays, that is to say they are too impure for the one purpose and too good for the other.

In the manufacture of stoneware, it is highly essential that the clay should burn to a dense impervious body without requiring too high a temperature to accomplish this, and furthermore if the ware is to be unglazed or is to be coated with a transparent glaze it is important that the clay should burn to a good uniform color. In order to obtain the desired result it is not uncommonly the rule to use a mixture of two or more clays for this purpose.

A stoneware clay should be smooth, and free from coarse grit, otherwise it may be necessary to wash the material, and thus increase the cost of manufacture. The clay, in addition, should be highly plastic in order to permit its being easily moulded without cracking, and the tensile strength should be not less than 150 pounds per square inch. As the ware is to be burned to a vitrified body, it is also desirable that there should be a difference of 150° to 250° F. between the point of vitrification and viscosity. (Earthenware clays are not vitrified.) Excessive plasitcity is undesirable as it necessitates very slow drying and burning of the ware and consequently increases the cost of manufacture; while on the other hand low shrinkage diminishes the loss from cracking or warping.

Iron is a desirable ingredient not only as it tends to give the body a good red color, but in addition serves as a flux. Lime if present as a silicate may form a

desirable flux, but carbonate of lime especially if in greater quantities than two or three per cent. is objectionable, and sulphate of lime is likewise not desired as owing to its disassociation at high temperatures blisters may be formed.

A clay vitrifying at a low temperature is more desirable as it requires fuel to burn it.

The pottery clays reported on are all from the Tuscaloosa formation of the Lower Cretaceous except No. 204 from Blount county, and No. 192 from near Rock Run, both of which come from the Paleozoie limestone formations.

(No. 204.)

STONEWARE CLAY

FROM F. S. WHITE, BLOUNT CO.

A very fine grained sedimentary clay of grayish white color with occasional spots of yellow.

It slakes easily when thrown into water and works up to a very plastic mass with 28 per cent. of water. The bricklets made from this had an air shrinkage of 5 per cent.

Then burned at 2200° F. it is nearly dense, cream gray in color and showed a total shrinkage of 17 per cent.

At 2350° F. was vitrified and showed very light gray color and a total shrinkage of 20 per cent.

It fused at the time at cone 27 in the Deville furnace.

The tensile strength of the air dried briquettes was low, ranging from 45 pounds per square inch to 55 pounds per square inch.

The analysis of the clay yielded:

Analysis of Stoneware Clay, Blount Co. (No. 204).

Silica	61.50
Alumina	26.20
Ferric oxide	2.10
Lime	0.50
Magnesia	0.43
Alkalies	0.70
Ignition	7.29
	98.72
Total fluxes	3.73

While this clay is not highly refractory, at the same time it has about the right refractoriness to be used in the manufacture of stoneware, and owing to the dense body to which it burns, is exeellently adapted probably to mix with more opened grained clays, which require a good binding material.

(No. 192.)

POTTERY CLAY

FROM C. C. DAVENPORT, ROCK RUN, CHEROKEE CO.

A green clay, of extreme fineness of grain, great density and breaking with a conschiodal fracture. In water it slackens rapidly to a flocculent mass.

It took 30 per cent of water to work it up and it yielded a lean and somewhat granular mass, which had an air skrinkage of 9 per cent.

The bricklets made from this clay burn to a greenish brown color, and vitrify easily at about 2000° F.

At about 1800° F. incipient fusion occurs, with total shrinkage of 18 per cent., and color brown. The clay fuses to a glassy mass at about 2150° F.

The average tensile strength of the air dried briquettes was 62 pounds per square inch, with a maximum of 70 pounds.

The analysis of the clay shows as follows:

Analysis of Pottery Clay, Rock Run, Cherokee Co. (No. 192).

Silica	57.00%
Alumina	17.80
Ferric oxide	5.60
Lime	2.10
Magnesia	1.20
Alkalies	6.00
Ignition	9.45
	99.15
Total	14.90

The high percentage of fluxes accounts for its easy fusibility, and the best use for this material would perhaps be as a natural glaze. It is exceedingly fine grained. When a slip is made of it and No. 205 (clay from near Kymulga) dipped into it, at cone 3-4 it yielded a transparent glaze.

CHALK BLUFF, ELMORE COUNTY.

At this locality there is a high bluff of clay and sand. The section involves approximately:

Section at Chalk Bluff, Elmore Co.

Sand	6 feet
Yellow clay	4 feet
Dark sandy clay	12 feet
Plastic clay	10 feet

Both the dark sandy, and lower plastic clay were tested and yielded very promising results. The lower bed yields a stoneware clay, and the upper a brick clay. (See Nos. 101 and 122.)

(No. 101.)

STONEWARE CLAY.

CHALK BLUFF, ELMORE CO.

This is a reddish gray fine grained clay, containing much fine mica and also an abundance of organic matter. In water it slakes very slowly. The addition of 38 per

cent. of water to the air dried clay gives a fairly elastic mass, and bricklets made from this have an air shrinkage of 6 per cent. At 2100° F. the total shrinkage is 11 per cent., and the color of the burned clay is somewhat reddish. Incipient fusion occurs at this temperature, while vitrification takes place at 2200° F. with a total shrinkage of 13 per cent., the color of the clay when burned to this point being a dull red. Viscosity took place at 2600°, so that the clay is not to be classed as a fire clay, it would probably work however for vitrified ware. The tensile strength is exceedingly high, and runs from 300 to 384 pounds per square inch, and while there is considerable variation, at the same time even the lower figure is very great.

The chemical composition is:

Analysis of Stoneware Clay, Chalk Bluff, Elmore Co. (*No.* 101).

Silica	60.38
Alumina	20.21
Ferric oxide	6.16
Lime	.09
Magnesia	.720
Alkalies	1.80
Ignition	10.21
	99.570
Total fluxes	8.77

(Nos. 88 and 89.)

POTTERY CLAY.

McLEAN'S, EDGEWOOD, ELMORE CO.

Considerable clay is dug for pottery on the land of Mr. McLean, 4 miles from Prattville, along the line of the C. M. R. R. This clay occurs in large pockets surrounded by sand, it is chiefly of two kinds, i. e., a smooth plastic clay and a sandy one.

The former (No. 88) is very tough, and quite plastic.

In water it slakes in angular fragments, and when worked, requires 32 per cent. of water to develop its plasticity. The clay is rather fine grained, but with a conchidal fracture, and shows iron stains on its joint surfaces.

The tensile strength does not appear in this case to stand in direct relation to the plasticity, for the maximum is only 56 pounds per square inch, and the average 49 pounds.

The clay burns to a buff color, and a dense body, and is quite refractory.

The total shrinkage at 2350° F. is 18 per cent. At 2700 it is 18.05 per cent.

In the Deville furnace, at cone 30, the clay vitrified and showed no evidence of becoming viscous.

The second or sandy clay (No. 89) slakes very quickly. It gives a moderately plastic, but though not so tough a mass as the preceding. The tensile strength is however higher, being 74 pounds on the average, and 92 at the maximum.

The air shrinkage is 8.75 per cent; at 2200° F. the total shrinkage was 11 per cent.; at 2350° the total shrinkage was 12 per cent.

The clay fuses at cone 30 in the Deville furnace.

Associated with these stoneware clays is a bed of ochre which fuses easily to a brownish glass. Its composition is:

Analysis of Ochre, Edgewood, Elmore Co.

Silica	51.14
Alumina	30.13
Ferric oxide	8.35
Lime	tr.
Magnesia	tr.
Alkalies	tr.
Ignition	10.15
	99.77

(No. P. S.)

POTTERY CLAY (BLUISH.)

FROM McLEAN POTTERY, ELMORE CO.

A compact bluish clay which slakes rather quickly in water. It shows little grit to the taste. It required 20 per cent. of water to make a workable mass, which to the feel was smooth and plastic. This mud shrunk 6 per cent. in drying and an additional 6 per cent. in burning, giving a total shrinkage of 12 per cent. The average tensile strength of the air dried briquettes was 55 pounds per square inch with a maximum of 66 pounds. Incipient fusion occurred at 1950° F., vitrification at 2150° F. and viscosity at 2400° F.

The clay burns to a dense, smooth, bluish white body, and should make a good stoneware clay. In burning it had to be heated slowly.

The analysis of it is as follows:

Analysis of Pottery Clay, McLean's, Edgewood, Elmore Co. (No. P. S.)

Silica (total)	62.60
Alumina	26.98
Water	8.60
Ferric oxide	.72
Lime	.40
Magnesia	.36
Alkalies	.65
Moisture	.70
	101.01
Free silica	30.10
Total fluxes	2.13
Sepcifiy gravity	2.37

STONEWARE CLAY

FROM NEAR COOSADA, ELMORE CO.

This is a moderately fine grained but somewhat gritty clay, which however is quite plastic, requiring 26.25 per cent. of water to develop its plasticity.

The tensile strength was on the average 154 pounds, with a maximum of 170 pounds.

The air shrinkage amounted to 8.1 per cent.; at about 2200° F. the total shrinkage was 14 per cent., the clay at this temperature having burned nearly dense, and the brick being a brown gray color; at about 2300° F. the total shrinkage was 15 per cent., the brick was very hard, homogeneous, dense, and still of a brownish gray color though somewhat darker; at 2500° F. the brick was thoroughly vitrified, and showed a slight swelling, the shrinkage at this temperature being only 13.5 per cent. and the color remained unchanged except that it was slightly darker in shade. A test made of this clay in the Deville furnace showed that at cone 26 it had become viscous.

The composition of the clay is as follows :

Analysis of Stoneware Clay, Coosada, Elmore Co.

Silica	66.61
Alumina	21.04
Ferric oxide	2.88
Lime	.40
Magnesia	.58
Alkalies	.70
Water	7.00
	99.21
Total fluxes	4.46

(No. 1 S.)

POTTERY CLAY.

H. H. CRIBBS, TUSCALOOSA.

This is a whitish, fine grained clay with small amounts of grit, which slakes easily to small irregular grains and scales; it required 25 per cent. of water to mix it and gave a moderately plastic mass whose air shrinkage was 6 per cent. and fire shrinkage 4 per cent., giving a total shrinkage of 10 per cent.; briquettes made of this paste

had, when air dried, a tensile strength of 68 pounds per square inch and a maximum tensile strength of 78 pounds per square inch.

Incipient fusion occurs at 2000° F., vitrification at 2200° F. and viscosity at 2400° F.

The clay burns to a dense yellowish body; the composition of it is as follows:

Analysis of Pottery Clay, H. H. Cribbs, Tuscaloosa (No. 1, S.)

Total silica	65.35
Alumina	21.30
Water	7.35
Ferric oxide	2.72
Lime	.60
Magnesia	.86
Alkalies	tr.
Moisture	1.44
	99.62
Free silica (sand)	39.25
Total fluxes	4.18
Specific gravity	2.34

Another analysis of this white clay from the Cribbs bed was made by Dr. Wm. B. Phillips and is as follows.

Analysis of White Plastic Clay, Cribbs Place, Tuscaloosa, Ala.

Silica	62.25
Alumina	27.90
Lime	2.36
Ferric oxide	0.10
Loss at red heat	10.00
	102.61
Total fluxes	2.46

If coarse grained this clay would probably work for a low grade of fire brick, as its fusibility would probably be less. It would probably work for potters clay, although it would no doubt be desirable to add a clay possessing greater plasticity and tensile strength to it.

The comparative purposes there are given herewith the

tests of two Missouri clays quoted in Vol. XI of Missouri Geological Survey. The one has a much higher tensile strength however:

Analyses of Missouri Clays.

	1.	2.
Silica	65.82	66.26
Alumina	22.63	20.32
Water	7.42	7.80
Ferric oxide	1.81	2.30
Lime	.25	.63
Magnesia	.67	.48
Alkalies	1.72	2.04
Total fluxes	4.45	5.45
Incip. fusion	2000°	2000°F
Vitrification	2200°	2200°F
Viscosity	2400°	2400°F
Average tensile str., lbs. per sq. in.	87	122
Maximum tensile strength	98	135

No. 1 is from Waltman's, Barton Co., used for stoneware.
No. 2 is from Lanigan shaft, Moberly, Randolph Co.

In composition it also resembles somewhat two clays from Ohio.*

Analysis of Ohio Clays.

	1.	2.
Combined silica	25.40	27.68
Free silica	40.81	36.58
Alumina	21.18	22.95
Water	6.29	6.74
Ferric oxide	1.28	1.28
Lime	.51	.45
Magnesia	.18	.37
Alkalies	1.80	1.96
Moisture	1.65	2.05
Total fluxes	4.77	5.86

No. 1. Cooking ware clay, Laresville, Muskingum Co.
No. 2. Stoneware clay, Akron, Summit Co.

In all of these analyses it will be noticed that the percentage of alkalies is higher, but the total fluxes are nearly the same, except in the last one.

*O. Geol. Surv. VII, 1893.

In the case of the Ohio samples no physical tests have been made.

(No. 115.)

STONEWARE CLAY.

J. C. BEAN, TUSCALOOSA CO.

This is from the property of J. C. Bean, near Tuscaloosa, in S. 31, T. 20, R. 11. The bed of clay is 6 feet thick and overlain by 4 feet of white sand.

It is a rather fine grained dense clay, which slakes very slowly. On mixing with 36 per cent. of water, it gave a very plastic mass, whose air shrinkage was 11 per cent., at 2200° F. the clay burned a pinkish brown and showed a total shrinkage of 16 per cent., while at 2250° F. it burned a grayish brown with a total shrinkage of 18 per cent. Incipient fusion occurs at 2100° F., vitrification at 2300° F. and viscosity at cone 27 in the Deville furnace. Owing to the extreme plastice nature of the clay it was very hard to make briquettes which did not show evidence of flaws so that the tensile strength ranged from only 90 to 100 pounds per square inch, which is probably low. Specific gravity 2.40.

(No. 100.)

POTTERY CLAY.

J. C. BEAN, TUCALOOSA CO.

This is a rather fine grained clay, and at the same time a dense one. It contains an appreciable quantity of organic matter which not only increases the plasticity but also necessitates slow drying and burning of the material. The addition of 31.5 per cent. of water to the clay converts it into a very plastic mass, whose shrinkage in air drying amounted to 9 per cent. In burning incipient fusion occurs at 2100° F., at which point the total shrink-

age was 14 per cent. and the bricklet buff in color. At 2200° F. the shrinkage was 16 per cent and the bricklet grayish buff, while vitrification occurred at 2200° F. accompanied by a total shrinkage of 17 per cent. Viscosity took place at 2500° F. The tensile strength was only moderate, being 84 to 85 pounds.

The chemical composition is :

Analysis of Pottery Clay, J. C. Bean, Tuscaloosa Co. (No. 100).

Silica	60.03
Alumina	24.66
Ferric oxide	3.69
Lime	.13
Magnesia	.380
Alkalies	tr.
Ignition	11.342
	100.232
Total fluxes	4.20

(No. 32 S.)

STONEWARE CLAY.

ROBERTS' MILL, COAL FIRE CREEK, PICKENS CO.

A gray, tough, rather fine grained clay, which in water slakes somewhat slowly to a mixture of grain one-sixteenth to one-thirty-second of an inch in size. Taste gritty. Patches of fine sand and ore scattered through the clay, and associated with them are a few small flakes of white mica.

The clay when ground to 30 mesh and mixed with 21.8 per cent. water gave a workable mass of quite plastic character, which shrunk 4 per cent in drying and 8 per cent in burning, making a total shrinkage of 12 per cent.

Air dried briquettes of the clay had an average tensile strength of 117 pounds per square inch and a maximum strength of 142 pounds.

Incipient fusion occurred at 2000° F.; vitrification at 2200° F. and viscosity at 2400° F.

The clay burned to a stiff buff body, which deepens on hard firing.

The composition is as follows:

Analysis of Stoneware Clay, Roberts' Mill, Pickens Co. (No. 32 S.)

Silica (total)	68.23
Alumina	20.35
Water	6.10
Ferric oxide	3.20
Lime	.34
Magnesia	tr.
Alkalies	.74
Moisture	1.06
	100.02
Free silica (sand)	43.23
Total fluxes	4.28
Specific gravity	2.17

This clay might also serve for stoneware. It burns to a buff color.

In general composition this clay resembles somewhat a stoneware clay used at Zanesville, Ohio*, which is given below. It will be noticed however that while the per centage of total fluxes is very close, the individal ones differ somewhat in amount from those in the Alabama clay.

Analysis of Ohio Clay.

Silica (combined)	25.40
Alumina	21,13
Water	6.29
Ferric oxide	1.28
Lime	.51
Magnesia	.18
Alkalies	1.80
Moisture	1.65
	99.24
Free silica (sand)	40.81
Total fluxes	3.77

*Ohio Geo. Surv. VII, 193.

(No. 11 S.)

POTTERY CLAY.

CRIBBS PLACE, BEDFORD, LAMAR CO.

A dεrk-colored, tough blue clay, containing much organic matter. It is very dense, and slakes very slowly. No pyrite and few mica scales were noticeable.

It requires 45 per cent. of water to make a workable mass, which was extrremely plastic and fat. This clay shrunk 12.5 per cent. in drying and an additional 6.5 per ceat. in burning giving a total shrinkage of 19 per cent., which is a large amoumt. The tensile strength of this air dried briquette should be great, but on account of the excessive plasticity it was found hard to mould briquettes which were free from flaws, so that most of them broke at about 100 pounds per square inch. Incipient fusion occurs at 1900° F. Vitrification at 2100° F. and viscosity at 2300° F. The clay burns to a deep red, dense body.

The following is the composition of it.

Analysis of Pottery Clay, Cribbs' Place, Lamar Co. (No. 11, S.)

Total silica	60.9
Alumina	18.98
Water and organic matter	12.46
Ferric oxide	7.68
Lime	trace
Magnesia	trace
Alkalies	trace
Moisture	.90
	100.92
Free silica (sand)	37.92
Total fluxes	7.68
Specific gravity	2.313

The chief use of this clay wo"ld probably be as a bond for leaner clays, in the manufacture of courser grades of pottery, or perhaps sewer-pipe.

In burning it has to be heated very slowly to prevent cracking, and the same holds true of the drying. Its excessive plasticily is in part due to the contained organic matter.

(No. 27 S.)

STONEWARE CLAY.

J. B. GREEN, FERNBANK, LAMAR CO,

A dense, fine grained, compact, tough clay, that falls to pieces extremely slowly in water. No pyrite noticeable. Taste somewhat gritty.

It required 32.6 per cent. of water to make it work up, giving a plastic mass. The shrinkage in drying was 10 per cent., and an additional 7 per cent. in burning, making a total shrinkage of 17 per cent. The tensile strength as determined by pulling apart air dried briquettes of the clay was on the average 152 pounds per square inch with a maximum of 185 pounds per square inch.

Incipient fusion occurs at 1900° F., vitrification at 2100° F., viscosity at 2300° F.

The clay burns to a hard, impervious body, of a deep red color. There is considerable organic matter present in the clay, which adds somewhat to the plasticity.

The analysis of the clay is as follows:

Analysis of Stoneware Clay, Fernbank, Lamar Co. (No. 27 S.)

Silica (total)	69.50
Alumina	13.00
Water and organic matter	6.70
Ferric oxide	6.40
Lime	.25
Magnesia	tr.
Alkalies	tr.
Moisture	3.40
	99.25
Free silica (sand)	43.90
Total impurities	6.65
Specific gravity	2.305

This clay would probably work very well for stoneware.

(No. 71 S.)

POTTERY CLAY.

W. DOTY, FAYETTE CO.

A fine grained, red clay, with little coarse grit, and very few mica scales. Slakes quickly to fine grains. It required 34.3 per cent of water to work it into a mass of good plasticily, the bricklets made from it shrinking 7 per cent. in drying and an additional 6 per cent in burning, giving a total shrinkage of 13 per cent.

The tensile strength of the air dried briquettes, was on the average; 116 pounds per square inch, with a maximum of 155 pounds.

Incipient fusion occurs at 2000° F., vitrication at 2200° F., and viscosity at 2400°.

It burns to a dense hard body of a nice deep red color, which darkens as vitrification is approached.

The composition of the clay is as follows:

Analysis of Pottery Clay, W. Doty, Fayette Co. (No. 71, S.)

Silica (total)	65.58
Alumina	19.23
Water	5.50
Ferric oxide	4.48
Lime	tr.
Magnesia	tr.
Moisture	1.40
	96.19
Free silica (sand)	45.85
Total fluxes	4.48
Specific gravity	2.42

(No. 70 S.)

POTTERY CLAY.

W. DOTY, FAYETTE CO.

A fine grained, rather gritty, reddish clay. In water it slakes quickly to small irregular grains. The addition of 25 per cent of water gave a plastic mass, which shrunk 6.2 per cent. in drying and an additional 5.8 per cent. in burning, giving a total shrinkage of 12 per cent.

Briquettes of the air dried clay had an average tensile strength of 95 pounds per square inch, and a maximum of 151 pounds.

Incipient fusion occurred at 2000° F., and viscosity at 2400° F. The clay burns to a yellowish color at 2000°, but to a red at 2200°. The body of the burned clay is smooth and dense.

The clay analyzed as follows:

Analysis of Pottery Clay, W. Doty, Faette Co. (No. 70 S.)

Silica (total)	67.10
Alumina	19.37
Water	6.08
Ferric oxide	2.88
Lime	tr.
Magnesia	.725
Alkalies	.672
Moisture	1.71
	98.537
Free silica (sand)	43.93
Total fluxes	4.27
Specified gravity	2.416

In compositon this clay resembles some-what a clay used for pottery and sewer pipe, and obtained at Gilkerson Ford, Henry Co., Mo.*

*Mo. Geol. Survey XI, p. 328.

The composition of this clay is:

Analysis of Clay, Henry Co., Mo.

Silica	67.49
Alumina	21.11
Water	5.95
Ferric oxide	2.45
Lime	.17
Magnesia	.63
Alkalies	2.83
	100.63
Total fluxes	6.08
Specific gravity	2.23

The shrinkage in both drying and burning is six per cent. and the tensile strength in 110 on the average, with a maximum of 127. Incipient fusion begins at 2000° F. complete vitrification at 2300°F., and viscosity at 2400° F.

(No. 68 S.)

POTTERY CLAY (REFRACTORY).

SHIRLEY S MILL, FAYETTE CO.

A fine grained, compact clay, with little coarse grit, but considerable fine sand. Color drab. It slakes very slowly to scaly grains.

Three per cent. of water were required to make a workable paste which was quite plastic. This paste shrunk 10 per cent. in drying and 4 per cent. in burning, giving a total shrinkage of 14 per cent.

The tensile strength of the air dried briquettes showed an average of 106 lbs. per square inch, and a maximum of 123 lbs.

The clay burns to a yellowish white body. Incipient fusion occurs at 2000° F., vitrification at 2200° F., and viscosity at 2400° F., The composition of the clay is as given below:

Analysis of Refractory Pottery Clay, Shirley's Mill, Fayette Co., (No. 68 S.)

Silica (total)	72.20
Alumina	17.42
Water and loss	7.40
Ferric oxide	2.40
Lime	trace
Magnesia	trace
Alkalies	.56
Moisture	.12
	100.10
Free silica (sand)	52.31
Total fluxes	2.96
Specific gravity	2.28

This clay might work for an inferior grade of fire brick, or also for pressed brick of a light color, or even for potter's clay. It resembles rather closely in composition a stoneware clay from Commerce, Scott Co., Missouri,* agreeing closely in every respect except the tensile strength. For sake of comparison the properties of the Commerce clay are given herewith:

Analysis of Clay, Commerce, Mo.

Silica	71.78
Alumina	17.01
Water	8.13
Ferric oxide	2.01
Lime	.34
Magnesia	.43
Alkalies	.78
	100.48
Total fluxes	3.56
Specified gravity	2.03
Incipient fusion	2000° F.
Vitrificaton	2200° F.
Viscosity	2400° F.
Average tensile strength	225 lbs. per sq. inch
Maximum tensile strength	254 lbs. per sq. inch

*Mo. Geol. Survey, XI, 350.

(No. 23 S.)

STONEWARE CLAY.

HEZEKIAH WIGGINS, FAYETTE CO.

A light gray, hard, compact clay, of moderately silicious character and containing a few scattered mica scales. It slakes very slowly to tough scaly flakes.

In order to make a workable paste the clay required the addition of 34.3 per cent. of water. This paste was markedly plastic. Its shrinkage in drying was 14 per cent. and 8 per cent. in burning, giving a total shrinkage of 22 per cent. The tenacity of the air dried mass was on the agerage 232 lbs. per square inch with a maximum of 300 lbs. per square inch; which is exceeded by comparatively few clays.

Incipient fusion occurs at 1900° F., vitrification at 2100° F., and viscosity at 2300° F. The clay burns to a dense red body, but requires slow drying and heating to avoid cracking.

The composition of this clay is as follows:

Analysis of Stoneware Clay, H. Wiggins, Fayette Co. (No. 23 S.)

Silica (total)	63.27
Alumina	19.68
Water	6.05
Ferric oxide	3.52
Lime	1.30
Magnesia	tr.
Alkalies	1.20
Moisture	3.75
	98.77
Free silica (sand)	39.59
Total fluxes	**6.02**
Specific gravity	**2.82**

The clay agrees in composition in a general way with some of the stoneware clays of Missouri and Ohio, and its shrinkage and tensile strength are similiar to a ston

ware clay from Harrisonville, Cass Co., Mo.,* but the latter having nearly 3 per cent. more fluxes fuses at a lower temperature.

(No. 65a. S.)

POTTERY CLAY.

TEN MILES SOUTHEAST OF HAMILTON, MARION CO.

A moderately gritly, medium grained clay with a few mica scales, it required 28.9 per cent. of water to make a workable mass, which is rather lean. The air shrinkage of bricklets made from this was 6.5 per cent. with an additional shrinkage of 5.5 per cent. in burning, making a total shrinkage 12 per cent.

The average tensile strength of air dried briquettes was 58 lbs. per sq. inch with a maximum of 6.5 lbs. per square inch.

Incipient fusion occurs at 1950° F., vitrification at 2150° F., and viscosity at 2350° F.

It burns to a grayish buff color.

The chemical composition is as follows:

Analysis of Pottery Clay, 10 miles southeast of Hamilton, Marion Co. (No. 65a, S.)

Silica (total)	70.00
Alumina	21.31
Water	6.35
Ferric oxide	2.88
Lime	.20
Magnesia	tr.
Alkalies	tr.
Moisture	.50
	101.24
Free silica (sand)	45 80
Total fluxes	3.08
Specific gravity	2.10

*Mo. Geol. Survey XI, p. 315.

(No. 62 S.)

POTTERY CLAY.

THOMAS ROLLINS, FRANKLIN CO.

A fine-grained tough clay, which slakes very slowly when thrown into water, but splits very easily along thin sandy layers which occur at intervals of about every half inch, a few mica scales are present, the addition of 20 per cent. of water gave a workable and quiet plastic paste.

The shrinkage of bricklets made from this paste was 10 per cent. in drying, and 4 per cent. in burning, or a total of 14 per cent.

The average tensile strength of air dried briquettes was 102 lbs.per square inch, with a maximum of 127 lbs. per square inch.

Incipient fusion occurs at 1900° F., vitrification at 2100° F., and viscosity at 2300° F. The clay burns to a red-gray, but has to be heated very slowly,

The composition of the clay is as follows:

Analysis of Pottery Clay, Thomas Rollins, Franklin Co. (No. 62, S.)

Total silica	67.50
Aumina	19.84
Water	6.15
Ferric oxide	6.15
Lime	.12
Magnesia	.10
Moisture	1.50
Total	100.97
Free silica (sand)	43.46
Total fluxes	5.90
Specific gravity	2.36

(No. 55 S.)

POTTERY CLAY (REFRACTORY.)

J. W. WILLIAMS, PEGRAM, COLBERT CO.

A white clay of fine grain, which slakes easily in water. The addition of 26 per cent. of water gave a lean

workable mass which shrunk 5 per cent. in drying, and 10 per cent. in burning, giving a total shrinkage of 15 per cent. The average tensile strength of air dried briquettes per sq. inch is 30 lbs, and the maximum tensile strength per sq. inch is 35 lbs.

Incipient fusion occurs at 2150 F., vitrificataon at 2300 F., and viscosity at 2500 F.; the clay burns to a dense yellowish white body.

Following is the composition of the clay:

Analysis of Pottery Clay J. W. Williams, Pegram, Colbert Co. (No. 55 S.)

Total silica	66.45
Alumina	18.53
Ferric oxide	2.40
Water	8.68
Lime	1:50
Magnesia	1.25
Alkalies	tr.
Moisture	.78
	99.59
Free silica (sand)	44.22
Total fluxes	5.15
Clay base	49.44
Specific gravity	2.39

This clay could probably be purified by washing, it corresponds in general composition to a fire clay from Parker and Russel's Mine* near St. Louis Mo., but the latter on account of its greater coarseness, has a larger refractoriness.

BRICK CLAYS.

The term brick clays is a somewhat elastic one for it may include those used for the manufacture of common brick, front or pressed brick, and paving brick. As the requirements are somewhat different they can be mentioned briefly and apart.

Clays for common brick. For this purpose almost any

*Missouri Geol. Survey. Vol. XI, p. 570.

clay suffices, in fact so little attention is applied to material used for this purpose, that the product is often soft and porous. Clays for common brick should not be excessively sandy, otherwise the brick will be weak and porous. They should possess sufficient plasticity to mould without cracking, but not be so plastic as to warp, due to excessive shrinkage. Most brick clays burn red. Ferruginous clays can be more safely burned to a hard product than clacareous ones, which burn buff or cream colored.

The methods used for moulding common brick are the *soft mud*, by which the soft plastic mass is forced into the mould; and *the stiff mud*, in which the clay is forced from a die of rectangular cross section and then cut up into bricks. The latter method gives greater capacity, but the bricks unless thoroughly burned will not stand the weather as well. Very plastic clays and very lean ones are adapted to the stiff mud process, the former because they are not tenacious enough, the latter because owing to their pastiness and the structure of the machine a laminated structure is developed in the brick.

Brick clays should have a tensile strength not less than 50 lbs. per square inch. They are not required to stand a high degree of heat, a few common brick kilns attain a temperature of over 1800 or 1900 degrees Fahr.

The more rapidly the clay slakes the easier will it be to temper it.

Clays for front or pressed brick. For this purpose a lighter grade of clay is required, and the material must not only burn to a hard body but also to a uniform color, for on the latter depends much of the beauty of the structure. In no branch of the clay working industry is the range of colors producible from natural clay mixtures more carefully considered than in the manufacture of pressed brick.

Many shades are obtained either by mixing two or more clays, or by adding artificial coloring agents to the raw materials.

Clays for front brick should shrink evenly in burning, and not warp nor crack. Straightness of outline and evenness of size are essential to close fitting when set in the wall.

Many front brick are moulded by the dry-press process, in which the clay is forced into the mould in the form of a dry powder. Such bricks have straight edges and smooth surfaces, but unless burned good and hard they chip easily. At many localities the clay is moulded in soft mud or stiff mud machines, and the brick, while still soft, re-pressed in a second machine whereby the surfaces are smoothed even and the edges straightened. These latter brick do not tend to exhibit the same brittleness along the edges as the dry press brick are apt to.

Front brick sell from \$15.00 to \$70.00 per 1000, depending on the color and shape.

Clays for paving brick. The nature of these must be such that they can be burned to vitrification. To do this economically and on a large scale the points of vitrification and viscosity should be at least 125° F. apart and preferably 200° F. If they were not it would be impossible to bring a kiln full of bricks to vitrification without running them up to the temperature of viscosity. For this reason calcareous clays are not well adapted to paving brick manufacture.

Paving brick clays should possess moderate or good plasticity so that they can be moulded by the stiff mud process, and while it is desirable that the tensile strength should be 75 pounds or more, at the same time many good pavers are made from mixtures whose tensile strength is not over 50 pounds per square inch.

Shales are used to a large extent for the manufacture

of paving brick, partly because many of them contain about the right quantity and kind of fluxing impurities, and also because, owing to the fineness of grain, they vittrify more evenly and thoroughly.

Paving brick are at times made from fireclay, and the results obtained are excellent, but still shale is the favored material.

Except for comparing brick made from the same deposit, the color is absolutely no indication of the quality of a paving brick.

The important properties which a paving brick should show are low absorption (under 2 per cent.) and resistance to abrasion. Crushing strength is of little importance provided it exceeds say 8,000 pounds per square inch.

The brick clays described below come from several geological formations. The Graves' shales, Nos. 107 and 108; the Coaldale shale and the Pearce Mill shale, No. 3, are Carboniferous shales. The Dixie clay and No. 128 and 129 of Mr. Stevens, are from the Poleozoic limestones, while the rest, No. 110 from Shirley's Mill, No. 122 from Chalk Bluff, Elmore Co.; No. 126 of Mr. Stevens, from Woodstock; No. A, from Tusealoosa Co., are from the Tuscaloosa formation of the Sower Cretaceous.

(Nos. 107 and 108.)

BRICK-SHALES.

W. H. GRAVES, BIRMINGHAM, JEFFERSON CO.

Associated with the coal on the property of Mr. W. H. Graves are two beds of shale, viz: a yellow, sandy shale, and a gray one containing much less grit. Both of these were tested physically and the results of these tests are given below. The yellow shale contains a high per cent-

age of ferric oxide and fuses very easily, while the gray shale contains several per cent. less, and is much better adapted to the manufacture of vitrified wares. The composition and physical characters of the two are given side by side for the purposes of comparison.

Light or gray shale, No. 108.

Plasticity, quite good. The shale takes 25 per cent. of water to work it up.

Air shrinkage 2 per cent.

Shrinkage at 2000° F., 9 per cent. Brick good red color not, very porous.

Shrinkage at 2200° F., 12 per cent. Brick reddish brown, and just about vitrified.

Fusion a 2500° F.

Tensile strength—average 105 pouuds, minimum 85 pounds per square inch.

Dark or yellow shale, No. 107.

Plasticity moderate; shale gritty, requires 20 per cent. of water to work it up.

Air shrinkage 1½ per cent.

Shrinkage at 2000° F., 5 per cent. Brick good red color. Somewhat porous.

Shrinkage at 2150° F., 6½ per cent, Brick nearly dense, reddish towards brown.

At 2250° F., nearly vitrified.

Fusion at 2500° F.

Tensile strength only 40 pounds to square inch.

Analysis of shales, Birmingham, Jefferson Co. (No. 107 and 108.)

	(108)	(107)
Silica	57.80	61.55
Alumina	25.00	20.25
Ferric oxide	4.00	7.23
Lime	2.10	tr.
Magnesia	80	.986
Ignition	7.50	6.19
Alkalies	1.80	2.25
	99.00	98.466
Total fluxes	8.70	8.45
Specific gravity	2.12	2.23

The gray shale burns to a denser, harder body than the yellow, and does not blister as easily in burning owing to its lower per centage of iron.

PAVING BRICKS SHALE,

COALDALE, ALA.

A yellowish red, soft shale, with considerable grit. No mica or pyrite noticeable.

Ground to 30 mesh and mixed with 22 per cent. of water it gave a lean paste, which shrunk 4 per cent. in drying and 5.5 per cent. in burning, giving a total shrinkage of 9.5 per cent.

The tensile strength of the air dried briquettes was on the average of 25 pounds per square inch with a maximum of 35 pounds.

Incipient fusion occurs at 1900° F., vitrification at 2000° F., and viscosity at 2150° F.

The shale burns to a red body and makes a good red brick. It is also used for paving brick.

(No. 33.)

RED SHALE,

PEARCE'S MILLS, MARION CO.

There is an an extensive outcrop of partially weathered Carboniferous shale along the private road of Mr. Pearce just before reaching the millls. It is a red, rather fine grained material, and contains a small amount of mica. Its soft character renders the mining of it an easy matter. When ground the shale gives a moderately plastic mass whose plasticity could no doubt be increased by weathering. Forty per cent. of water were required to work it up, and the bricklets made from this material had an air shrinkage of 4 per cent. When burned to 2000°

F., the total shrinkage was 8 per cent., and the color of the bricklet was a rich red. At 2100° F., the color of the bricklet was the same, and the shrinkage was 9 per cent., incipient fusion having occurred at this point. Vitrification occurs at 2200° F., and the color is deep red, while viscosity took place at about 2300° F. In drying the clay showed little evidence of containing any appreciable quantity of soluble salts that would tend to form any efflorescence, nor did any show themselves afetr burning.

The comparatively small shrinkage and the rich red color to which the clay burns would make it admirably adapted to the manufacture of pressed brick, but unless it was mixed with a more plastic clay it would hardly work for the production of terra cotta.

The semi-weathered character of the material would also facilitate the preparation of it.

(No. A.)

PAVING BRICK CLAY,

TEN MILE CUT, TUSCALOOSA CO.

The sample of this clay was collected by the writer from what is known as the Ten Mile Cut on the M. & O. R. R., west of Tuscaloosa. It is a somewhat gritty clay, which contains thin seams of sand. The general color of the clay is bluish-gray, but here and there it shows stains of limonite especially on the sandy fractures. When thrown into water it slakes and gives in working a somewhat gritty, but quite plastic mass, which requires 26.00 per cent. of water to work it up.

The air shrinkage of the clay amounted to 8½ per cent. while at 2200° F., it was only 10 per cent., and at 2300° F., 12 per cent., at which point incipient fusion occurred.

Vitrification took place at cone 27 in the Deville furnace and fusion above cone 30.

The tensile strength of the air dried briquettes varied from 126 to 144 pounds per square inch with an average of 140 pounds. The clay burns to a buff color, and is to be classed as a refractory one although it is not highly so. Its location is excellent for cheap working, and easy shipment of the product, and while it has been put under the head of paving brick clays there is no reason why it should not find uses in other directions as well.

The chemical composition of this clay is as follows:

Analysis of Paving Brick Clay, Tuscaloosa Co. (No. A.)

Silica	72.70
Alumina	19.61
Ferric oxide	.934
Alkalies	.80
Ignition	6.50
	100.544
Total fluxes	1.734

PRESSED BRICK CLAY,

DIXIE POTTERY CO., OXFORD, CALHOUN CO.

This is the clay used by the Dixie Tile and Pottery Co. For the manufacturer of buff brick, the clay is quite plastic, and considering this fact it does not seem to require an extraordinary amount of water to work it up. The amount used being only 25.75 per cent. The average tensile strength is 130 pounds per square inch, with a maximum of 144 pounds. In air drying the clay shrunk about 10 per cent; at about 2200° F. incipient fusion began, and up to this point the clay had burned a buff color but then began to burn to a grayish tint; vitrification took place at 2400°, and the total shrinkage to this point was

18 per cent. The clay fused or became viscous at 2600° F. The following is a composition of it:

Analysis of Pressed Brick Clay, Oxford, Calhoun Co.

Silica	71.80
Alumina	17.16
Ferric oxide	1.94
Lime	.60
Magnesia	.43
Alkalies	.95
Ignition	7.60
	99.98
Total fluxes	3.92

This clay should make a good buff colored ware if burned at a comparatively low temperature, but if burned to vitrification the color would of course be much darker as indicated by the test, and owing to the high shrinkage in burning it would be necessary to conduct the latter slowly and with care to prevent cracking of the clay.*

(No. 110.)

PRESSED BRICK CLAY.

SHIRLEY'S MILL, FAYETTE CO.

The clay from this locality is a very fine grained dense one, but at the same time breaks up very easily.

It took 33 per cent. of water to work it up, and the air shrinkage of the bricklets was 6 per cent.

Incipient fusion occurs at 2100° F.

Vitrification took place at 2200° F. and at this point, the bricklet showed a total shrinkage of 16 per cent., and a deep cream color.

In the Deville furnace, at cone 27, the clay became viscous.

*These bricks are well known in Alabama, and deserve to be even more generally usd than they are. E. A S.

While this clay is not to be looked upon as a refractory one, it would seem that owing to the beautiful color, to which it burns, it would be highly desirable for the manufacture of pressed brick.

The composition of the clay is:

Analysis of Pressed Brick Clay, Shirley's Mill, Fayette Co. *(No. 110.)*

Silica	71.32
Alumina	20.10
Ferric oxide	1.05
Lime	tr.
Magnesia	.316
Alkalies	tr.
Ignition	7.505
	100.291
Total fluxes	1.366
Specific gravity	1.90

(No. 122.)

BRICK CLAY.

CHALK BLUFF, ELMORE CO.

The upper half of the clay bed at this locality is composed of a dark, dense, grayish brown clay which contains a large amount of organic matter, either in a finely divided condition or in the form of leaves. Although not sandy, at the same time it is rather lean when mixed up with water, and owing to the presence of so much organic material absorbed 40 per cent. of water when it was being worked up to a plastic mass. The air shrinkage was however only 6 per cent. At 1900° F. it had reached a total of 14 per cent., but the bricklet was still very absorbent; at 2100° F. incipient fusion had been reached and the total shrinkage was 18.7 per cent., while the color was brownish red; and at about 2200° F. the total shrinkage was 20 per cent. and the color brown, and this color had deepened considerably at 2250° F. with the ap-

appearance of vitrification ,while the maximum shrinkage amounted to 21 per cent. Viscosity was obtained in the Deville furnace at cone 27.

This clay therefore shows an appreciable and safe distance between vitrification and viscosity. The tensile strength is however low, averaging 75 pounds per square inch, with a maximum of 97 pounds per square inch, and a minimum of 68 pounds. Specific gravity, 2.41.

(No. 26 A. Stevens.)

BRICK CLAY.

WOOKSTOCK, BIBB CO.

This is quite a plastic clay, which requires 29 per cent. of water to produce its maximum plasticity. The air shrinkage was 6 per cent., and the average tensile strength was 101 pounds per square inch, with the maximum of 104 pounds. The fire test gave the following results:

At 2250° F., the shrinkage 10 per cent, clay incipiently fused, color buff.

At 2400° F., shrinkage 11 per cent., color a dark buff.

At 2500° F., clay vitrified, color reddish.

Viscosity occurs at cone 27 in the Deville furnace.

The composition of the clay is:

Analysis of Brick Clay, Woodstock, Bibb Co. (No. 126 A. Stevens.)

Silica	74.20
Alumina	17.25
Ferric oxide	1.22
Lime	.30
Magnesia	.40
Alkalies	tr.
Ignition	7.35
	100.72
Total fluxes	1.92

(No. 129, Stevens.)

BRICK CLAY.

BIRMINGHAM.

This is a very dense hard clay, which required considerable grinding to break it up. The different lots were mixed up, and the one, A, being composed of two-fifths of the clay which was passed through 20 mesh sieve, and thee-fifths of particles greater than 20 mesh.

The second lot, B, was made up entirely of that which had passed through the 20 mesh sieve.

Both lots gave a rather lean mass, but A required 19 per cent. of water and B 16 per cent. to work up. The average tensile strength of A is 12 pounds, and that of B 35 pounds. The air shrinkage of both was 4 per cent.

In burning to 2300° F. the shrinkage of A was 3 per cent, the color of the bricklet a full yellow, and the body very absorbent. At 2400° F. incipient fusion occurred in both cases, and the color of the bricklet was a brownish gray, and the total shrinkage 10 per cent.

At 2500° F. the clay was vitrified, of a dull brownish gray color, and showed a very homogeneous fracture.

Viscosity occurred at 2700° F.

The chemical composition of the clay is:

Analysis of Brick Clay, Birmingham. (No. 129 Stevens.)

Silica	67.30
Alumina	16.10
Ferric oxide	7.77
Lime	tr.
Magnesia	tr.
Alkalies	tr.
Ignition	9.25
Total fluxes	100.42

(No. 128, Stevens.)

BRICK CLAY.

ARGO, JEFFERSON CO.

This was a very plastic smooth clay, which took 22.20 per cent. of water to work it up. The tensile strength varied from 120 to 136 pounds per square inch. The air shrinkage was 7½ per cent. The behavior of the clay at other temperatures was as follows:

At 2250° F. the shrinkage was 12 per cent., color yellowish gray.

At 2300° F. the shrinkage and the color the same, but incipient fusion had begun.

At 2500° F. the clay was vitrified, and the total shrinkage was 14 per cent. In the Deville furnace, at cone 27, the clay became thoroughly viscous.

It could not therefore be called a very refractory clay, but would work no doubt very well for pressed brick or for other purposes.

The composition of the clay is as follows:

Analysis of Brick Clay, Argo, Jefferson Co. (No. 128 Stevens.)

Silica	72.87
Alumina	18.03
Ferric oxide	2.00
Lime	.61
Magnesia	.42
Alkalies	.53
Ignition	6.62
	101.08
Total fluxes	3.56

MISCELLANEOUS CLAYS.

These are all derived from the Tuscaloosa formation of the lower Cretaceous.

(No. 67 S.)

CLAY FROM W. D. BAGWELL'S,

SEVEN MILES NORTH OF FAYETTE COURT HOUSE, FAYETTE CO.

A gritty clay, that slakes slowly but completely to fine grains.

The clay required 28 per cent. of water to make a washable mass, which was slightly plastic and gritty. This paste shrunk 6 per cent. in drying and 3 per cent. in burning, giving a total shrinkage of 9 per cent.

The average tensile strength of the air dried briquettes was 45 pounds per square inch, with a maximum of 53 pounds.

Incipient fusion occurred at 2100° F., vitrification at 2250° F., and viscosity at 2409° F.

The clay burns to a deep buff color.

Its composition is as follows:

Analysis of Clay from W. D. Bagwell, Fayette Co. (No. 67. *S*.)

Silica (total)	75.70
Alumina	14.36
Water	4.45
Ferric oxide	4.64
Lime	tr.
Magnesia	tr.
Moisture	1.24
	100.39
Free silica (sand)	58.60
Total fluxes	4.64
Specific gravity	2.26

(No. 40 S.)

CLAY FROM H. PALMER,

BEXAR, MARION CO.

A gritty, fine grained clay, containing scales of mica, which slakes easily and quickly to irregular grains.

It required 26 per cent of water to make a workable

paste, which to the feel was very slightly plastic and it tasted gritty. In shrinkage in drying was 6 per cent. and 3 per cent. in burning, making a total shrinkage of 9 per cent.

Air dried briquettes of the mud had an average tensile strength of 66 pounds per square inch, and a maximum tensile strength of 68 pounds per square inch.

Incipient fusion occurred at 2000° F.; vitrification at 2160° F. and viscosity at 2300° F.; at 2000° F. it burns to a buff, but on retrifying it becomes red in color.

The composition of the clay is as follows:

Analysis of Clay, H. Palmer, Bexar, Marion Co. (No. 40 S.)

Silica (total)	71.33
Alumina	21.88
Water	5.54
Ferric oxide	.32
Lime	.234
Magnesia	.305
Moisture	1.05
	100.659
Free silica (sand)	46.45
Fluxes	.859
Specific gravity	2.305

(No. 12.)

CLAY FROM H. PALMER,

BEXAR, MARION CO.

A fine grained clay, with sandy laminae and mica scales between the layers. It slakes slowly to fine particles and grains of sand.

The clay required the addition of 31 per cent. of water and gave a moderately plastic mass, that shrank 5 per cent. in drying and 3 per cent. in burning, making a total shrinkage of 8 per cent. The briquettes made from this paste had, when air dried, an average tensile strength

of 85 pounds p.r square inch, with a maximum of 89 pounds per square inch.

Incipient fusion occurs at 1950° F., complete vitrificatioh at 2150° F., and viscosity at 2350° F. The clay burns to a yellowish red body.

Its composition is as follows:

Analysis of Clay, H. Palmer, Bexar, Marion Co. (No. 12)

Total silica	69.93
Alumina	20.15
Water	5.90
Ferric oxide	1.38
Lime	.42
Magnesia	tr.
Alkalies	tr.
Moisture	1.20
	98.98
Total fluxes	1.80
Specific gravity	2.28

(No 41 S.)

MOTTLED CLAY.

BEXAR, MARION CO.

A very open grained, sandy clay, with scattered scales of mica and occasional iron stains. It slakes very quickly to its component mineral grains.

It required 39 per cent. of water to work it up. It is slightly plastic, and shrunk 6 per cent. in drying with an additional 11 per cent. in burning, making a total shrinkage of 17 per cent.

Air dried briquettes of the mud had an average tensile strength of 15 lbs. per square inch, and a maximum of 80 lbs. per square inch.

Incipient fusion occurs of 2000° F., vitrification at 2150° F., aud viscosity at 2300. The clay burns to a red, but not very smooth body.

The clay analyzed as follows:

Analysis of Mottled Clay, Bexar, Marion Co. (No. 41 S.)

Silica (total)	72.40
Alumina	14.86
Water	5.05
Ferric oxide	7.64
Lime	.20
Magnesia	.40
Moisture	.65
	101.20
Free silica (sand)	55.20
Fluxes	8.24
Specific gravity	2.445

(No. 18 S.)

BLUE CLAY.

THIRD CUT NEAR GLEN ALLEN, MARION CO.

A very fine-grained soft clay with little grit, which slakes very readily on being thrown into water.

It required 28 per cent. of water to make a workable mass which was slightly plastic. The shrinkage of this paste in drying was 8.3 per cent., and in burning 7 per cent., giving a total shrinkage of 15.3 per cent. The tensile strength of the air dried briquettes was 56 lbs. per square inch on the average, with a maximum of 65 lbs. per square inch.

Incipient fusion occurs at 1950° F., vitrification at 2150° F., and viscosity at 2350° F.

The clay burns to a light bluff.

The composition on analysis was found to be as follows:

Analysis of Blue Clay, R. R. Cut, near Glen Allen, Marion Co. (No. 18 S.)

Silica (total)	68.10
Alumina	21.89
Water	5.05
Ferric oxide	2.01
Lime	.80
Magnesia	.28
Alkalies	.40
Moisture	.70
	99.230
Free silica (sand)	41.60
Total	4.19
Specific gravity	2.44

The fineness of grain is probably accountable for the low tensile strength and comparatively low temperature of vitrification and fusion. As far as the composition is concerned it is not unlike some of the potters clays used it the United States, but its low tensile strength would probably act against its utility for this purpose, unless mixed with a more plastic clay. For building materials it would no doubt work all right. Being of fine uniform grain permits the production of a very smooth surface on the ware.

(No. X. S.)

CLAY FROM W. J. BECKWITH'S.

COLBERT CO.

A moderately fine-grained, homogeneous, brittle, porous clay, with a semi-couchoidal fracture. In water it slakes slowly to particles mostly under one-sixteenth inch in size.

When mixed with 28 per. cent. of water it gave a lean mass of somewhat gritty feel, which shrunk 5 per cent. in drying and 6 per cent. in burning, or a total shrinkage of 11 per cent. The clay had to be dried and burned slowly to prevent cracking.

Air dried briquettes made of the mud had an average tensile strength of 22 lbs. per square inch, and a maximum strength of 38 lbs.

Incipient fusion occurs at 2050° F., vitrification at 2250° F., and viscosity at 2450° F.

The clay burns to a deep buff body, and requires careful heating to avoid cracking.

An analysis of the material gave the following results:

Analysis of Clay, W. J. Beckwith, Colbert Co. (No. X S.)

Silica (total)	58.20
Alumina	29.86
Water	9.12
Magnesia	tr.
Lime	.20
Ferric oxide	2.22
Alkalies	tr.
Moisture	1.18
	100.78
Free silica	22.59
Total fluxes	2.44
Specific gravity	2.18

THE UTILIZATION OF CLAY FOR PORTLAND CEMENT.

Aside from being used for the manufacture of clay products, there remains the possibility of using some of the Alabama clays for the manufacture of Portland cement. The three essential elements of this material are lime, silica and alumina. The first of these is supplied by limestone, marl or chalk, while the other two are contained in clay.

In the manufacture of Portland cement the two materials are ground and intimantely mixed after which they are burned to vitrification. During the burning certain compounds are formed, especially calcic aluminates and silicates, whose union with water and subesquent crystallization causes the cement to set. The mixture of clay and limestone is manipulated so that in the finished product, the per centage of lime shall be equal to 2.8 times the silica plus 1.1 times the alumina and to maintain this constancy requires that the composition of the materials used must be constantly watched.

While it is possible to get a proper cement mixture from materials showing an appreciable range in composition, at the same time care must be exercised. Highly

siliceous clays or limestones are undesirable, the materials used often contain ferric oxide, magnesia or alkalies.

Their affect according to Shewberry is as follows: Ferric oxide combines with lime at a high heat and acts like alumina in promoting combinations of silica and lime. For practical purposes the presence of ferric oxide in a clay need not be considered in calculating the amount of lime required.

Alkalies so far as indicated by the bebavior of soda, are of no value in promoting the combination of silica and lime, and probably play no part in the formation of cement.

Magnesia though possessing marked hydraulic properties when igniled alone, yields no hydraulic products when heated with clay, and probably plays no part in the formation of cement, and it is incapable of replacing lime in cement mixtures.

The following analyses taken from the 1897 Mineral Industry will give an idea of the composition of clays used in portland cement, while following them are several Alabama occurence that could no doubt be used in cement manufacture.

FOREIGN CLAYS.

LOCALITY.	SiO_2	Al_2O_3, Fe_2O		$CaCO$	CaO	$MgCo_3$	MgO	Ign.
Glens Falls, N. Y.	55.27	28.15			5.84		2.25	8.50
Warner's, N. Y	40.48	20.95		25.80		.99		11.90
Sandusdy, O	64.70	11.90	9.90		.90		.70	7.90
Bronson, Mich	62.10	20 09	7.81		.65		.96	12 08
Yankton, S. D	57.98	18.26	4.57		1.75		1.83	5.16
White Cliff, Ark	53.30	23.29	9.52		.36		1.49	6.12
" " "	65.12	19.05	7.66		.34		.31	
Medway, Eng.	63.66	16.16	6.74		.81		1.73	
Belgium, Beerse clay	65.50	18.55	6.01		.38		1.18	
Stettin, Germany	54.60	18.20	5.40		2.80		13.16	13.10

ALABAMA CLAYS.

LOCALITY.	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	Alk.	Ign.
H. H. Cribb's, Tuscaloosa	63.35	21.30	2.72	.60	.86	....	7.35
Prattville	62.60	26.98	.72	.40	.36	.65	8.60
Birmingham, Graves' Mine	57.80	25.00	4.00	2.10	.80	1.80	7.50
W. J. Beckwith, Colbert Co	58.20	29.86	2.24	.20	tr.	tr.	9.12
Pearce's Mill	52.95	35.10	.80	tr.	tr.	.93	11.40
Bedford, Lamar Co.	60.90	18.98	7.68	tr.	tr.	tr.	13.46

It is not necessary to give more than a few, additional cases being given in the preceding pages.

Limestone and marl or chalk is to be found at many localities within the State, so that both the materials used for Portland cement are available.

With the increasing use of this material, and the absence of any factories in the South, it would seem that Alabama offers an excellent field for the establishment and operation of several.

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